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## Notes on the Identities and Distributions of *Aedes* Species of Northern Canada, with a Key to the Females (Diptera: Culicidae)<sup>1</sup>

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In the Northern Insect Survey, sponsored jointly by the Canada Department of Agriculture and the Department of National Defence, the insect fauna of northern Canada was investigated extensively during the summers of 1947-52. The research work has centred on the biting flies and has consisted in large part of taxonomic studies, as a preliminary to biological investigations. In mosquitoes of the genus *Aedes*, the difficulty of identifying the adult females, particularly those of the black-legged groups, has made biological studies extremely difficult.

A major part of the field work of the survey parties has, therefore, consisted of rearing adult mosquitoes. Many of these were reared individually from larvae, and were preserved with the larval exuviae. These have provided long series of adult females identified to species for use in a search for new characters for identifying wild-caught specimens. Many more were reared from pupae and provide unrubbed specimens for further study.

This preliminary report includes a revised key to the adult females, brief notes on characters important in identifying females, and an outline of the distribution of each species. A few comments are made on the larvae and males, which offer few difficulties in identification; the former have been treated by Rempel (1950) and both by Matheson (1944). No detailed descriptions are given; these can be found in the works referred to above.

The most satisfying key for identifying North American *Aedes* females is that given by Gjullin (1946). However, additional characters—the shape of the tarsal claws, the presence or absence of a post-coxal scale patch, the arrangement and abundance of the postpronotal setae, and the colour of the mesonotal and scutellar bristles—are of value. These characters are used to a considerable extent in the accompanying key. The pleural bristles and scale patches used in identification are designated in Fig. 16.

The shape of the tarsal claws is an excellent specific character in many species, but it must be determined with caution as a change in the angle from which the claw is examined causes an apparent change in the shape of the claw. This difficulty can be overcome by removing the terminal tarsal segment and pressing the claws flat under a cover slip in water, glycerine, or balsam. A magnification of X40 is usually satisfactory for examining mounted or unmounted tarsal claws. In the species treated here, except *Aedes vexans* (Mg.) and *A. cantator* (Coq.), the claws of all legs of the females are of the same shape, and those of the hind legs of the male are of the same shape as those of the female of the species. This fact often allows identification of male specimens without an examination of the genitalia.

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The post-coxal scale patch is found on the membranous area between the anterior coxa and the sternopleuron. It seems to be a specific character, unlike the hypostigial scale patch, which may be present or absent in different specimens of the same species. It was used by Knight (1951) to define the *Aedes punctor* subgroup; it is sometimes, however, of considerable value in separating specimens of otherwise very similar species.

Unfortunately, the scales, and to a lesser extent the bristles, especially those of the mesonotum, fade during the life of a mosquito. I have direct evidence that this is so in *Aedes nigripes* (Zett.) and indirect evidence for other species. Specimens of *A. nigripes* taken at Spence Bay, N.W.T., July 2, 1951, have the mesonotal scales a deep bronzy-brown; series taken at intervals during the next month have the scales progressively paler, and specimens taken on August 6 have the mesonotal scales silvery-white. This fading can cause considerable difficulty in identifying specimens captured more than a few days after emergence and indicates that structural characters and colour pattern, rather than actual colour, should be utilized whenever possible. The colours of scales and bristles given in the key are those of recently emerged specimens.

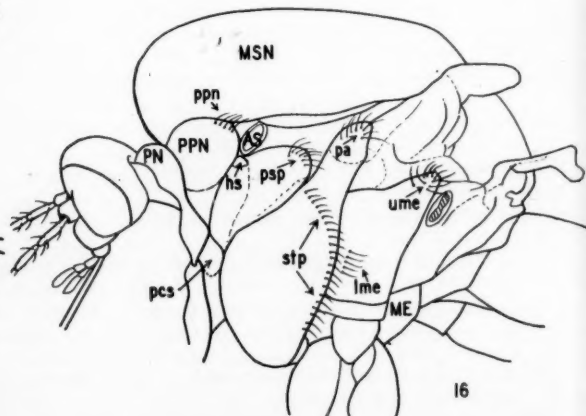
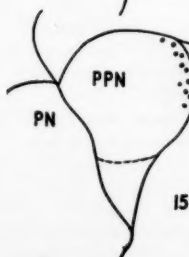
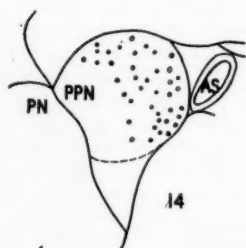
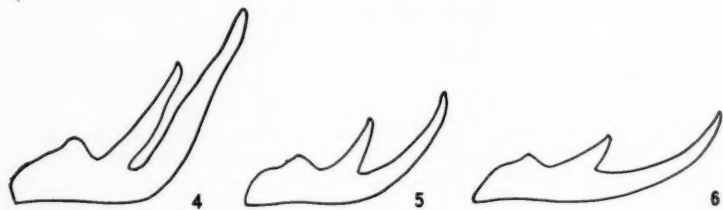
The area so far covered in the Survey consists roughly of the northern half of the Boreal forest and the entire Arctic tundra of Canada. Geographically, it includes the region north of a line drawn through Fort Nelson, B.C.; Gillam, Man.; Moose Factory, Ont.; Knob Lake in central Quebec; Goose Bay, Labrador; and Harmon Field and Gander, Nfld. This includes, of course, all of the Yukon Territory and the Northwest Territories.

Most of the distribution records obtained in the Survey have already been published (Freeman, 1952); only a few additional records of any significance have been obtained. These records seem extremely scattered, but in such a vast area it is difficult to collect at more than widely separated localities, and it is felt that the records give a fairly accurate picture of the distribution of the species of *Aedes* in northern Canada.

#### Key to the *Aedes* Females of Northern Canada

1. Tarsal segments ringed with white ..... 2  
Tarsal segments not ringed with white ..... 12
2. Bases and apices of tarsal segments ringed with white ..... 3  
Bases only of tarsal segments ringed with white ..... 6
3. Wings with dark and light scales on most of the veins ..... 5  
Wings almost entirely dark-scaled ..... 4
4. Base of costa with white scales ..... *atropalpus* (Coq.)  
Costa entirely dark-scaled ..... *canadensis* (Theo.)
5. Dark and light scales usually uniformly distributed on wing veins; tarsal claw as in Fig. 1 ..... *campestris* D. & K.  
Third vein ( $R_1+5$ ) usually with more dark scales than second ( $R_2+3$ ) or fourth ( $M$ ); tarsal claw as in Fig. 2 ..... *dorsalis* (Mg.)
6. Basal white bands of tarsal segments very narrow, on the hind tarsi less than one-fourth as long as the segments ..... 7  
These bands broad, on the hind tarsi about one-third as long as the segments ..... 8
7. Basal pale bands of anterior abdominal tergites narrow and indistinct; meteusternum with scales; lower mesepimeral bristles present ..... *cantator* (Coq.)  
Basal pale bands of anterior abdominal tergites distinct; meteusternum bare; lower mesepimeral bristles absent ..... *vexans* (Mg.)
8. Large yellowish species, abdominal tergites almost completely yellow-scaled; tarsal claw as in Fig. 3 ..... *flavescens* (Müll.)  
Abdominal tergites with abundant dark scales ..... 9

9. Tarsal claw very large; main claw almost parallel with tooth and slightly sinuate (Fig. 4) ..... *excrucians* (Walk.)  
Tarsal claw smaller, not so sharply bent beyond tooth ..... 10
10. Mesonotum almost uniform yellowish-brown; tarsal claw as in Fig. 5 ..... *riparius* D. & K.  
Mesonotum with dark median stripe; tarsal claw as in Fig. 6 ..... 11
11. Sides of mesonotum usually yellowish; lower mesepimeral bristles usually three to five in number ..... *stimulans* (Walk.)  
Sides of mesonotum greyish; lower mesepimerals usually one or two, or absent ..... *fitcbii* (F. & Y.)
12. Very small species; tergites with a metallic gleam, without basal white bands; fore coxa with a patch of brown scales on the anterior surface ..... *cinereus* Mg.  
Larger species; tergites with basal white bands (except in *diantaeus* and *pseudodiantaeus*); fore coxa with white scales only ..... 13
13. Post-coxal scale patch (Fig. 16, *pcs*) present ..... 14  
Post-coxal scale patch absent ..... 21
14. Hairy species; postpronotum with setae scattered over the posterior half (Fig. 14) ..... 15  
Less hairy species; postpronotum with setae in a single or an irregular double row along the posterior margin (Fig. 15) ..... 16
15. Tarsal claw sharply bent (Fig. 7) ..... *impiger* (Walk.)  
Tarsal claw elongate (Fig. 8) ..... *nigripes* (Zett.)
16. Mesonotum with scales along lateral margin silvery grey; median lines largely pale brown, broad, poorly defined; base of costa with a distinct patch of numerous white scales; bristles of scutellum and of mesonotum blackish ..... 17  
Mesonotum with scales along lateral margin yellow or dark, not silvery grey; median lines, when present, narrow; base of costa with at most a very few pale scales ..... 18
17. Basal seventh of costa white-scaled; veins C, Sc, and R with a few scattered white scales; tibiae and basitarsi anteriorly with many white scales; tarsal claw as in *communis* (Fig. 11) ..... *cataphylla* Dyar  
White scales of wing restricted to extreme base of costa; tibiae and basitarsi with fewer white scales anteriorly; tarsal claws short, less sharply bent (Fig. 9) ..... *implicatus* Vock.
18. Bristles of scutellum and of mesonotum all or almost all black; tarsal claw as in Fig. 10 ..... *pionips* Dyar  
Bristles of scutellum and of mesonotum yellow or bronzy ..... 19
19. Mesonotum with sharply defined dark-brown median line or lines; lateral margins of mesonotum yellow-white to yellow-brown; tarsal claw as in Fig. 13 ..... *punctor* (Kirby)  
Mesonotum almost uniform brown, sometimes with indications of a median line due more to the arrangement than to the colour of the scales ..... 20
20. Base of costa with a patch of pale scales ..... *bexodontus* Dyar  
Base of costa dark-scaled ..... *abserratus* (F. & Y.)
21. Mesonotum uniform bronzy or with very faint indications of median lines ..... *intrudens* Dyar  
Mesonotum with distinct median line or lines contrasting in colour with the marginal scales ..... 22
22. Hypostigial scale patch (Fig. 16, *hs*) present ..... *pullatus* (Coq.)  
Hypostigial scale patch absent ..... 23
23. Basal white abdominal bands distinct; bristles of scutellum and of mesonotum black or bronzy-black ..... 24  
Basal white abdominal bands indistinct or absent; bristles of scutellum and of mesonotum almost always bright yellow; tarsal claw slender, elongate (Fig. 12) ..... 26
24. Median mesonotal stripes greatly expanded on anterior half of mesonotum, separated from margins by only a narrow border of yellow scales; tarsal claw elongate as in *pionips* (Fig. 10) ..... *rempeli* Vock.  
Median mesonotal lines narrower, uniform in width throughout; tarsal claw more sharply bent (Fig. 11) ..... 25
25. Mesonotal pattern not well defined, rather variable; sides of mesonotum yellow or greyish; lower mesepimeral bristles present ..... *communis* (Deg.)  
Mesonotal pattern more sharply defined; sides of mesonotum yellowish-white; lower mesepimeral bristles absent ..... *sticticus* (Mg.)





26. Occiput and postpronotum usually with numerous dark scales; sternopleura with 1-4 setae anterior to and below lower end of mesepimeron ..... *pseudodiantaeus* Smith  
 Occiput without, postpronotum at most with only a few, dark scales; sternopleura with 7-12 setae anterior to and below lower end of mesepimeron .... *diantaeus* H., D., & K.

***Aedes abserratus* (Felt and Young)**

*Aedes implacabilis* auct. (non Walker)

This species is widespread in eastern Canada and the northeastern United States, but it apparently occurs only along the southern boundary of the area of the Survey. It has been taken at Moose Factory, Ont.; Goose Bay, Labrador; and St. Anthony and Harmon Field, Nfld.

The post-coxal scale patch offers a more reliable character for separating this species from *intrudens* Dyar than does the colour of the abdominal sternites, although the latter might serve to separate most specimens of the two species. In *A. hexodontus* Dyar the mesonotal scales are usually blackish-brown; in the few specimens of *abserratus* I have examined the scales are bright bronzy-brown. Also, *hexodontus* Dyar is a much more northern species; the two have not yet been found at the same locality, although they may occur together on the coast of Labrador or in northern Newfoundland.

***Aedes atropalpus* (Coquillett)**

This species has been recorded from the survey area only at Goose Bay, Labrador, where larvae were collected. It is widespread but local in eastern North America. It probably goes little farther north than Goose Bay, but occurs south through the eastern United States, Mexico, Central America, and northern South America.

***Aedes campestris* Dyar and Knab**

This is mainly a species of the western plains, where it has a wide distribution, but it is found sparingly as far north as the tree line. It has been taken at Whitehorse, Y.T., and Churchill, Man., in moderate numbers, but, despite extensive collecting, it has not been found in the region between these points.

According to Ross (1947) the colour of the wing scales is a very unreliable character for separating this species from *dorsalis*, as in one population of the latter species great variation may occur. The tarsal claws of *campestris* (Fig. 1) are, however, very different from those of *dorsalis* (Fig. 2); they offer a reliable character for identifying adults of both sexes.

Figs. 1-13. Fore tarsal claw of female: 1, *Aedes campestris* D. & K. 2, *A. dorsalis* (Mg.). 3, *A. flavescens* (Müll.). 4, *A. excrucians* (Walk.). 5, *A. riparius* D. & K. 6, *A. fitchii* (F. & Y.). 7, *A. impiger* (Walk.). 8, *A. nigripes* (Zett.). 9, *A. implicatus* Vock. 10, *A. pionips* Dyar. 11, *A. communis* (Deg.). 12, *A. diantaeus* H., D., & K. 13, *A. punctator* (Kirby).

Figs. 14-15. Postpronotum, showing arrangement of setae of: 14, *Aedes impiger* (Walk.). 15, *A. hexodontus* Dyar.

Fig. 16. Lateral view of head and thorax of *Aedes* female, showing characters used in identification (after Gjullin).

**Abbreviations**

AS, anterior spiracle; ME, meteusternum; MSN, mesonotum; PN, pronotum; PPN, postpronotum; hs, hypostigial scale patch; lme, lower mesepimeral setae; pa, prealar setae; pcs, post-coxal scale patch; ppn, postpronotal setae; psp, postspiracular setae; stp, sternopleural setae; umc, upper mesepimeral setae.

*Aedes canadensis* (Theobald)

This is one of the most widely distributed species of *Aedes* in North America. It is found in woodland from the Gulf of Mexico almost up to the northern limit of trees, and is abundant throughout the forests of northern Canada. It has been taken as far north as Norman Wells, N.W.T. Series of reared mosquitoes from Harmon Field and Gander, Nfld., consisted almost entirely of *canadensis*. Elsewhere in northern Canada it is much less abundant than any of several black-legged species.

*Aedes cantator* (Coquillett)

This species was not known from the survey area when distribution maps were published by Freeman (1952). It was previously known from eastern North America, from Nova Scotia to Virginia; it breeds in coastal marshes and in saline pools or fresh water inland. In 1951 adults of both sexes were reared from larvae at St. Anthony, Nfld.; this greatly extends the known northward limits of the species.

*Aedes cataphylla* Dyar

This species is abundant in most parts of the Rocky Mountains from Utah and Colorado to Alaska. In the survey area it is known only from Whitehorse, Y.T. Matheson (1944) and Rempel (1950) record the species from Waskesieu, Sask., on the basis of specimens collected by Rempel. The Canadian National Collection has one male and two females collected by Rempel at Waskesieu under the label *cataphylla*; one of the females has been determined by Matheson as of *A. cataphylla*. The male is a specimen of *A. implicatus* Vock.; the females are not identifiable, but are not of *cataphylla*. It is possible that other specimens in this series are of *cataphylla*, but I think it unlikely that the species occurs east of the Rocky Mountains. *A. cataphylla* is widespread in northern Europe, where it is not restricted to mountainous areas.

*Aedes cinereus* Mg.

This species occurs in abundance throughout the forested area of northern Canada, and north to the tree line at Churchill, Man., and probably elsewhere. It has been recorded throughout the forested areas of Canada and the northern United States. It is widely distributed in the northern part of the Palearctic region. The species is easily recognized by its very small size, uniform dark-brown mesonotum, and very short palpi in both sexes.

*Aedes communis* (Deg.)

This is the most abundant species of mosquito in the survey area. It is essentially a forest species, and its range extends south into the wooded areas of the northern United States, but it breeds farther north than any of the other species of the Boreal forest. At Padlei, N.W.T., a short distance beyond the limit of trees, larvae and adults of *communis* were abundant, and at Great Whale River, Que., just south of the tree line, it was the commonest mosquito. It is very abundant, also, in the Palearctic region.

The morphological differences between this species and *Aedes pionips* Dyar have been discussed by Vockeroth (1952). Unfortunately the value of the post-coxal scale patch as a specific character was not appreciated when that paper was written; it is undoubtedly the most reliable means of separating the two species. The shape of the tarsal claws (Fig. 10, 11) and the mesonotal colour pattern (much less sharply defined and more variable in *communis* than in

*pionips*) are also useful characters for separating the females. The males of *communis* have the palpi longer than the proboscis and the last segment enlarged at the tip; the palpi of males of *pionips* are shorter than or rarely subequal to the proboscis, and the last segment is slender. The hind tarsal claws of males differ as do those of the females; and the postcoxal scales, absent in *communis*, are present in *pionips*, although they are usually fewer than in the females.

Recent studies at Fort Churchill, Man., have shown that in this area a species of mosquito, morphologically indistinguishable from *communis*, does not attack humans and probably does not take blood of any kind (Hocking, 1952). Matheson (1944) and Natvig (1948) both refer to *communis* as a severe biter; the Fort Churchill specimens may belong to a local, physiologically distinct race, or to a species distinct from *communis*. In view of the similarity of females of *communis* to the females of other species and the difficulty of identifying specimens in the past, it is possible that *communis* will be found to be non-biting over the whole of its range.

#### *Aedes diantaeus* Howard, Dyar and Knab

This species, too, is typical of the forested areas of Canada and the northern United States. It is never abundant and does not extend north to the tree line. It is found in northern Europe, where it is rare and local also.

The females of *diantaeus* and *pseudodiantaeus* Smith are very similar and cannot always be reliably separated, although the characters given in the key serve to identify most specimens. The male and larvae are discussed under *pseudodiantaeus*.

#### *Aedes dorsalis* (Meigen)

This is a species of the open regions of the United States and Canada. It is very abundant on the prairies, in salt marshes of the coasts, in flood waters, and in irrigated areas. Adult females were taken in large numbers at Rupert House, Que., but the larvae were not found. This is the only record of the species in the survey area.

The shape of the tarsal claws (Fig. 2) allows both males and females to be readily distinguished from those of *campestris*.

#### *Aedes excrucians* (Walker)

This species has been recorded from almost every northern Canadian locality, from the tree line southwards, where collections have been made, but it is never the most abundant species. It is found throughout the forested areas of Canada and the northern United States, and across northern Europe and Asia.

The female of *excrucians* may very readily be separated from that of any other Canadian species of *Aedes* by the shape of the tarsal claws.

#### *Aedes fitchii* (Felt and Young)

The distribution of *fitchii* in North America seems to be very similar to that of *excrucians*, but the former is not found as far north. It has not yet been reported from localities at or very near the tree line.

The separation of adult females of *fitchii* and *stimulans* is still so difficult that unquestionable identifications can seldom be made. *Fitchii* is somewhat smaller than *stimulans*, but size is a poor criterion. Other than this, the characters given in the key are all that are at present known. They are not very reliable. The males and larvae of the two species are, fortunately, distinct from one another.

*Aedes flavescens* (Müller)

This large, distinctive, yellow-scaled species is rare in northern Canada. It occurs as far north as the tree line at Churchill, Man., but has been recorded at only very few localities in the northern forested area. It is widespread and abundant in the prairie and parkland regions of Canada and the United States, and occurs in Europe and in Asia.

The tarsal claws (Fig. 3) are very large and elongate, and should serve as a ready means of identification for even badly rubbed specimens.

*Aedes hexodontus* Dyar

The examination of large numbers of larvae and adults, many of the latter associated with larval skins by individual rearing, has led me to agree with Knight (1951) that the *Aedes punctor* group in northern Canada consists of two closely related but distinct species. One of these is abundant in the forested areas and occurs in small numbers as far north as the tree line; for this species the name *punctor* Kirby is used. The other species is very abundant at the tree line; it is found in small numbers as far south as Norman Wells, N.W.T. and Gillam, Man., and occurs sparingly throughout most of the Arctic tundra. To this species Knight and Jenkins have applied the name *hexodontus* Dyar. The adults of this species can be distinguished from those of *punctor* only by rather slight differences; the larvae, however, are very distinct.

The larva of *punctor*, of which many have been examined, has an irregular double row of comb scales, from 10 to 21 in number (excepting one specimen only which had 7 scales on one side, 11 on the other). The comb scales are rather small—only 0.066-0.077 mm. in length. The length of the scales is independent of the number of scales present. The fifth prothoracic hair (Rempel, 1950; Belkin, 1950) is almost always single; only 8 of 156 larvae examined had this hair double on one or both sides.

In *hexodontus* larvae, on the other hand, the comb scales are 5 to 9 in number. Of 140 combs examined, only 1 had 5 scales, and 4 had 9 each; the others had 6, 7, or 8. The scales are noticeably larger than those of *punctor* (from 0.111 mm. to 0.133 mm. in length); under low magnification the size of the scales indicates immediately the species to which the larva belongs. Here, too, the size is independent of the number of scales. The fifth prothoracic hair is almost always double or triple; only 8 larvae out of 100 examined had this hair single on one or both sides.

The two forms are so similar that they might be suspected of being subspecies of one species. However, the two occur together in a number of localities. Whitehorse, Y.T., Norman Wells, N.W.T., and Great Whale River, Que., have both forms, although *punctor* is slightly more abundant. From Churchill, Man., 32 larvae of *hexodontus* and 1 of *punctor* were available and from Gillam, Man., 27 of *punctor* and 2 of *hexodontus*. At these localities the two remain distinct. No specimens with comb scales intermediate in size have been seen, and the number of comb scales and the number of branches of the fifth prothoracic hair show approximately the same range of variation in larvae of each form, whether they are from areas where both occur or from areas where only one or the other is found (Table I). If the two forms were subspecies this clear-cut difference would not exist; instead of a zone of overlap, with the two forms remaining distinct, a zone of intergradation would be expected.

TABLE I

Comparison of selected characters in larvae of *Aedes punctor* and *Aedes hexodontus*, only the most variable populations being included

Locality	Species present	Number of specimens	Number of comb scales	Fifth prothoracic hair single	Fifth prothoracic hair double or triple
<i>punctor</i>					
Calumet I., Que.	One	7	11-19 (1 with 7)	7	0
Gillam, Man.	Both	24	12-16 (1 with 10)	24	0
Meach L., Que. (Ottawa district)	One	4	—	3	1
Great Whale R., Que.	Both	41	—	38	3
<i>hexodontus</i>					
Churchill, Man.	Both	25	6-8 (1 with 9)	3	22
Padlei, N.W.T.	One	24	5-8 (2 with 9)	0	24
Frobisher B., Baffin I., N.W.T.	One	11	6-8 (1 with 9)	3	8

The adult females are usually quite as distinct as the larvae. *Aedes punctor* has the sides of the mesonotum yellow, and has a broad, dark-brown median mesonotal stripe which is only rarely divided by a very narrow line of yellow scales. The bristles of the scutellum and of the posterior half of the margins of the mesonotum are usually bright yellow, although occasionally they have a bronzy tint. The base of the costa is usually entirely dark-scaled, although one or two white scales may be present.

The females of *Aedes hexodontus* almost always have the mesonotum uniformly covered with brown scales, except for the pale antescutellar area. Only occasionally can a faint, darker, median stripe be seen, and it is always divided by a broad line of slightly paler scales. This median stripe is usually due to a difference in the arrangement of the scales; only very rarely are the scales actually darker in colour. The mesonotal and scutellar bristles, which are yellow in *punctor*, are dark bronze or almost black in *hexodontus*. The base of the costa has a rather large patch of pale scales.

Two specimens that may be of *punctor* (associated with larval skins), from Harmon Field, Newfoundland, differ markedly from the typical *punctor* described above. The mesonotum is covered with fine brown scales, and median lines are absent; they are indistinguishable from *abserratus*, but very different from typical *punctor* from the same locality. These may be the same as the "tundra" variety of *punctor* recorded by Knight (1951) from Reindeer Depot, N.W.T., and Umiat, Alaska (I have not seen these specimens), or they may represent an undescribed species of the *punctor* group. More specimens are necessary before the nature of these dark specimens can be understood.

All the specimens of *hexodontus* I have seen from northern Canada have the mesonotal markings relatively constant. However, several specimens from California, kindly sent to me by Mr. Benjamin Keh, Berkeley, Calif., have the mesonotal markings much more distinct, the ground colour paler than in the northern specimens, and the two submedian stripes separated by a broad line of paler scales. Three larvae from California compared well with northern speci-



mens, the fifth prothoracic hair being double. It is possible that *hexodontus* is made up of two clearly defined subspecies, but more specimens from the mountains of the northwestern United States and southwestern Canada will be necessary before the status of the two apparent populations is known.

The males of *punctor* and *hexodontus* are very similar. No structural differences could be observed. The males of *punctor* have the mesonotal scales paler and the markings more distinct than do those of *hexodontus*, but the differences are not nearly so marked as they are in the females. The scutellar and mesonotal bristles of the males differ in colour as do those of the females.

The name *punctor* Kirby is here applied to the species to which Dyar applied the name in 1919. He based his use of the name on Theobald's redescription of the "types" of *punctor*. These "types" were from St. Martin's Falls, Albany River, Ont., and are almost certainly Walker's specimens of 1848, whereas Kirby's types (the true types) were from the Mackenzie River valley, near Ft. Norman, N.W.T. However, Kirby's specimens were apparently denuded, their location is unknown, and they would almost certainly be unrecognizable; therefore the name may as well remain with the species to which it has applied since 1919.

The distribution of *punctor* and *hexodontus* in the survey area has already been outlined. *Punctor* occurs throughout most of the forested areas of Canada, and south into the mountains of the western United States and into New York and Massachusetts in the east. It has a wide distribution in the Palaearctic region. *Hexodontus* occurs in the mountains of California and Oregon, and probably in the higher mountains of Western Canada. It has not been recorded from the Palaearctic region, but I have collected many specimens at Abisko, Lapland, Sweden, and the species is probably abundant in the northern part of Europe and Asia.

#### *Aedes implicatus* Vockeroth

*Aedes impiger* auct. (non Walker)

This species, too, has a Boreal distribution; it occurs in the forested regions of Canada and the northern United States. It does not extend north to the limit of trees, and it is seldom abundant, although a large series of specimens was reared at Ft. Smith, N.W.T.

Females of this species can be confused only with those of *cataphylla* Dyar; the absence of white scales beyond the base of the costa in *implicatus* seems to be a constant recognition character.

#### *Aedes intrudens* Dyar

This species occurs along the southern border of the survey area, but is abundant throughout the southern part of the forested regions of Canada from the Atlantic to the Pacific, and in the northern United States. It has been reported from Alaska and occurs in Europe.

This is the only dark-legged species lacking post-coxal scales and having a uniform brown mesonotum.

#### *Aedes impiger* (Walker)

*Aedes nearcticus* Dyar et auct.

This is chiefly an Arctic species, although it occurs locally far south of the tree line. Rempel (1950) recorded it from Waskesieu, Sask., and I have seen specimens from Ft. Smith, N.W.T., and Gillam, Man. At Churchill, Man., the larvae are rather scarce, but at Padlei and Eskimo Pt., N.W.T., a short distance north of Churchill, they are abundant. Farther north *impiger* is almost replaced by *nigripes* Zett., although *impiger* apparently occurs throughout the Arctic.



In 1951 adult females were collected at Alert, Ellesmere Island ( $82^{\circ}30'N$ ); this is the most northerly record for any species of mosquito. It extends south along the Rocky Mountains into the United States, and is abundant in northern Europe.

As indicated by Gjullin, the colouring of the mesonotum is very variable. Specimens with extensive whitish scaling around the margin are common. The species is very hairy; the postpronotum has abundant setae on the posterior half (Fig. 15). If the hairs have been removed the points of attachment may usually still be seen. The tarsal claws (Fig. 7) allow almost certain identification; no other northern black-legged species of *Aedes* has claws of this shape. Some specimens of *communis* have claws similar to those of *impiger*, but they are never as sharply bent.

The hind tarsal claws offer a very useful means of separating males of *impiger* and *nigripes*, two species with similar genitalia. From all other species, except *pullatus*, the males of these two species may be separated by the extreme hairiness and very sparse scaling of the mesonotum. The genitalia of *pullatus*, however, are very different from those of *impiger* and *nigripes*.

#### *Aedes nigripes* (Zetterstedt)

This is the most abundant mosquito of the Arctic. The northern limit of its distribution is not known, although it probably occurs farther north than the distribution records given by Freeman (1952) indicate. At Resolute Bay, Cornwallis Island, N.W.T., no biting flies of any kind were taken by two entomologists stationed there throughout the summer of 1949; at Alert, Ellesmere Island ( $82^{\circ}30'N$ ), only *impiger* was taken; the northern limit of the distribution of *nigripes* is probably somewhere south of these two points. The southern limit of the range of *nigripes* seems to be the northern edge of the Boreal forest; it has been taken at Great Whale River, Que., and St. Anthony, Nfld. The latter is the southernmost locality at which *nigripes* has been taken. This species has not been recorded from the mountains of the western United States, or from Whitehorse, Yukon, where extensive collections have been made. The southern limit of its range in western North America is thus unknown.

*Aedes nigripes* may be readily distinguished from *impiger* by the elongate tarsal claw (Fig. 8), from *pullatus* by the absence of hypostigial scales, and from other species by the abundance of post-pronotal setae (Fig. 15).

#### *Aedes pionips* Dyar

This species is restricted mainly to the forests of northern Canada. In the west it extends south along the Rocky Mountains to Colorado. I know of no records of the species from the northeastern United States. It is sometimes very abundant, but usually less abundant than *communis*. At the tree line, where *communis* occurs in large numbers, *pionips* is extremely scarce. It has not been reported from Europe.

Characters for the recognition of *pionips* are discussed under *Aedes communis* (Deg.).

#### *Aedes pseudodiantaeus* Smith

This species probably occurs throughout the sub-arctic region of Canada, although so far it is known, in Canada, only from Goose Bay, Labrador. Smith (1952), however, reports it from Alaska and the northeastern United States.

The female is very similar to that of *diantaeus* but can usually be distinguished by the characters given in the key; the males may be separated by the huge brush of hairs on the basistyle (directed inward in *diantaeus*, backward in *pseudodiantaeus*), and the larvae by the setae at the apex of the antenna (three long setae in

*diantaeus*, one long seta in *pseudodiantaeus*), and by the number of comb scales (6-13 in *diantaeus*, 5-7 in *pseudodiantaeus*). These characters are given by Smith.

***Aedes punctor* (Kirby)**

This species is discussed under *Aedes hexodontus* Dyar.

***Aedes pullatus* (Coquillett)**

The distribution of this species in North America is very remarkable. It has, in the past, been reported from a number of localities in the Rocky Mountains from Alaska to Colorado, and has recently been recorded from central California, where it occurs near the timber line in the mountains (Johnson and Thurman, 1950). It was thus thought to have a distribution in North America similar to that of *cataphylla*. However, in 1948 *pullatus* was collected at Frobisher Bay, Baffin Island, and Ft. Chimo, Que., in 1949 at Pt. Harrison and Great Whale River, Que., and in 1951 at St. Anthony, at the northern end of Newfoundland. At Great Whale River it was, next to *communis*, the most abundant mosquito (Knight & Jenkins, 1950). As Baffin Island and Port Harrison are definitely Arctic, and the other three localities are very near the tree line, the species might be expected to occur across the northern tundra. Yet despite intensive collecting at Churchill, Man., Chesterfield Inlet, N.W.T., and a large number of other Arctic localities, not a single specimen of *pullatus* has been taken on the barren grounds west of Hudson Bay, and the species may be assumed to be absent from the region between Hudson Bay and the Rocky Mountains. It has been recorded from Michigan (Irwin, 1941); in the absence of confirmation I would doubt this record. The northern Quebec and Baffin Island population may be specifically distinct from *pullatus*, but no differences have been found in larvae, males or females.

The species occurs in northern Europe and has been recorded from Kamchatka in eastern Siberia. It is possible that it originated in the Palaearctic region and that it has invaded eastern North America from Europe, and western North America from Siberia. If this is so, it would be expected to occur in Greenland, but as far as I know, it has not been recorded there. Natvig (1948) discusses in some detail the distribution of *pullatus* in Fennoscandia, and suggests glacial refuges for the species during the most recent glaciation. A similar explanation for the distribution of *pullatus* in North America cannot be discounted, but the presence of such a glacial refuge in Labrador is considered very doubtful. At present, therefore, I am quite unable to explain this discontinuous distribution, which is not duplicated by that of any other species of Nearctic mosquito.

Specimens of *pullatus* are usually easy to recognize. It is the only Arctic species that lacks the post-coxal scale patch. The hypostigial scale patch is large and distinct. On each side of the broad median mesonotal stripe are two almost bare lines, each with only a few very dark scales. The base of the costa is extensively white-scaled.

***Aedes rempeli* Vockeroth**

This is undoubtedly the rarest of all the Canadian species of *Aedes*. Only three specimens are known: a male and a female from Padlei, N.W.T., and a male from Great Whale River, Que. At both these localities large numbers of mosquitoes were reared; it seems not unlikely that the species occurs across the continent at or near the tree line, but is everywhere rare.

In the key given by Matheson (1944), the larva of *rempeli* keys to *trivittatus* (Coq.), but the latter has a shorter, broader air-tube, with the pecten reaching

the middle, and the dorsal hair of the dorsal brush of the anal segment short and multiple instead of long and double or triple as in *rempeli*. The male keys to *nigripes* (Zett.) or *bimaculatus* (Coq.); *rempeli* is much less hairy than the former, and has a much more northern distribution than the latter. The female may be separated from other species by the characters given in the key.

***Aedes riparius* Dyar & Knab**

This is a species of the southern part of the northern forests, and of the northern edge of the Great Plains. It apparently extends into the United States in both the east and the west. Rempel reports it in abundance at Lac la Ronge, Sask., but very few specimens have been taken in the survey area. It has been taken at Churchill, Man., and Norman Wells, N.W.T., but it is not at all abundant at these localities.

The almost uniform yellowish- to reddish-brown mesonotum and the rather elongate tarsal claws (Fig. 5) readily distinguish *riparius* from the other band-legged species of the *flavescens* group.

***Aedes sticticus* (Meigen)**

This species is abundant across the northern United States and southern Canada. In the survey area it was taken only once, at Moose Factory, Ont. It occurs, also, in Europe.

The females are similar to those of *communis*, but the median mesonotal stripe is more sharply defined and the sides of the mesonotum are paler.

***Aedes stimulans* (Walker)**

This is still another of the species that reach their maximum abundance in the forested area of Canada and the northern United States. The distribution coincides almost exactly with that of *fitchii*; neither species appears to extend quite to the tree line in the north as does *excrucians*.

The form of the tarsal claws separates this species from all the members of the *flavescens* group except *fitchii* and probably *increpitus* (Vockeroth, 1950). The latter apparently does not occur in the north; from *fitchii*, *stimulans* may be separated by its slightly larger size, and by the characters given in the key; unfortunately, naming of females cannot, at present, be certain.

***Aedes vexans* (Meigen)**

This mosquito has an extremely wide distribution, being found in many parts of the Palaearctic, Oriental, and Nearctic regions. In southern Canada and in many parts of the United States it is one of the most abundant species of mosquitoes. As might be expected, it occurs only sparingly in the forested areas of northern Canada; Rempel reports it from Waskesiu, Sask., and single specimens have been taken at Whitehorse, Y.T., and Lower Post, B.C.

**Discussion of Distribution**

The distribution records of species of *Aedes* so far obtained in northern Canada indicate that the genus may be divided into groups, each composed of species with certain features of distribution in common.

By far the largest group consists of Boreal forest species. These extend across northern Canada in the forested areas, and reach down into the United States in both the east and the west. The exact distribution and relative abundance of these species vary greatly. Some are rare or comparatively rare everywhere, some are abundant in the more southern part of the forested area

and rare in the north, and a few are abundant from the southern to the northern limits of the Boreal forest. The group includes *canadensis*, *cinereus*, *communis*, *diantaeus*, *excrucians*, *fitchii*, *intrudens*, *implicatus*, *pionips*, *pseudodiantaeus*, *riparius*, *sticticus*, and *stimulans*. Of these, *diantaeus*, *implicatus*, and *riparius* are seldom common; *intrudens* and *sticticus* are abundant along the southern edge of the forests; *communis* and *excrucians* are widespread and abundant, and the remainder are most abundant in the centre of the Boreal area, occurring only very sparingly as far north as tree line. Of these species, all but *pionips*, *pseudodiantaeus*, *canadensis*, *implicatus*, *stimulans*, and *fitchii* occur in Europe.

Four species that are found in great numbers on the plains of central North America occur, in small numbers, varying distances into the forested regions of northern Canada. These are *flavescens*, *campestris*, *dorsalis*, and *vexans*. Of these, all but *campestris* occur in Europe.

Three species may be considered Arctic, and are the most abundant mosquitoes of most of the northern tundra. *A. nigripes* is truly Arctic, and does not appear to breed south of the tree line, except at coastal localities, or in the Rocky Mountains of Alberta, British Columbia, or the United States. *Aedes hexodontus* and *impiger* range throughout the Arctic, but are most abundant just beyond the tree line; they occur sparingly some distance south of the tree line, and in the mountains of the western United States. All three of these species are abundant in northern Europe.

*Aedes abserratus*, *atropalpus*, and *cantator* are apparently restricted to eastern North America, although *abserratus* extends as far west as James Bay and Illinois. None of these species is found in Europe.

Three species do not fall into any of these groups. *A. cataphylla* is found in the mountains of western North America, and in Europe. *A. pullatus* has a peculiar, discontinuous distribution, already discussed, in North America, and occurs also in Europe. *A. rempeli* is known from only two localities, one just north and the other just south of the tree line.

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## Notes on *Acrobasis rubrifasciella* Pack. (Lepidoptera: Phycitidae), with a List of its Parasites<sup>1</sup>

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In the Ottawa region about the middle of June, frequently certain leaves of the common alder, *Alnus rugosa* var. *americana* (Regel) Fern., are drawn together by strands of silk, concealing an elongate silken tube or case. The latter is occupied by an active brownish-grey larva that, when unmolested, extends itself from the broadly open end of the tube to feed on the foliage. This insect is the phycitid *Acrobasis rubrifasciella* Pack., a species that occurs in northeastern United States and adjacent parts of Canada.

During the summers of 1945 and 1951 the writer studied this species at Ottawa. Attention was directed mainly to the rearing of parasites, of which an account is given below, but a few notes obtained on the habits of the host are also offered as little has been previously published on this subject. A brief historical review of the species is included.

### Historical Review

#### *Acrobasis rubrifasciella* Pack.

Packard. 1873. *Ann. Lyc. Nat. Hist. N.Y.* 10: 267 [in part].—Grote. 1878. *Bull. U.S. Geol. and Geog. Surv. Terr.* 4: 693.—Beutenmüller. 1889. *Ent. Amer.* 5: 38 [misidentification].—Beutenmüller. 1890. *Can. Ent.* 22: 16.—Hulst. 1890. *Trans. Am. Ent. Soc.* 17: 124.—Packard. 1890. *Fifth Rept. U.S. Ent. Comm.* (U.S. Ent. Comm. Bull. No. 7, revised), p. 309 [in part].—Ragonot. 1893. *Monographie des Phycitinae et des Galleriinae*, St. Petersburg, p. 106.—Dimmock. 1898. *Proc. Ent. Soc. Wash.* 4: 150.—Ashmead. 1900. *Ann. Rept. N.J. Bd. Agr.* 27, suppl., p. 566.—Chittenden. 1903. *U.S. Dept. Agr. Yearb.* for 1902, p. 731 [misidentification].—Dyar. 1908. *Proc. Ent. Soc. Wash.* 10: 46.—Patch. 1908. *Maine Agr. Expt. Sta. Bull.* 162: 356 [misidentification].—Johannsen. 1910. *Maine Agr. Expt. Sta. Bull.* 177: 22 [misidentification].—Smith. 1910. *Ann. Rept. N.J. Mus.*, 1909, p. 533.—Ely. 1913. *Ins. Inscit. Menst.* 1: 56.—Gill. 1914. *Proc. Fla. Hort. Soc.* 27: 150 [reference not examined].—McDunnough. 1922. *Can. Ent.* 54: 26 [as *alnella*].—Forbes. 1923. *Cornell Univ. Agr. Expt. Sta. Mem.* 68: 617.—Viereck. 1926. *Can. Ent.* 58: 220.—Leonard. 1928. *Cornell Univ. Agr. Expt. Sta. Mem.* 101: 581.—McDunnough. 1933. *Can. Ent.* 65: 206 [*alnella* synonymized].—Procter. 1938. *Biological Survey Mt. Desert Region*, Part 6, p. 249. Philadelphia.—Raizenne. 1952. *Forest Lepidoptera of southern Ontario and their parasites*, p. 169. *Can. Dept. Agr., For. Biol. Div.*, Ottawa.

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This species was first described by Packard (1873) from specimens he reared from alder at Orono, Maine. His description included a brief account of the larval case and the pupa. He also assigned to this species certain specimens reared from sweetfern,<sup>3</sup> which, he observed, though indistinguishable in the adult stage and the pupa, were associated with larval cases that were strikingly different from those of the alder-feeder. These differences, which he carefully noted, he suggested might be attributed to differences in the foliage of the two food plants. Grote (1878) redescribed the adult, figuring the wing venation, and recorded the species from Maine and Massachusetts. Hulst (1890) treated the species in a synopsis of the genus *Acrobasis*, adding, with slight modification, a brief description of the larva as published by Beutenmüller (1890). Packard (1890), in his second account of the species, confused it with the sweetfern-feeding species [*A. comptoniella* Hulst], and two other species described by Grote [*A. demotella* and *A. angusella*], which feed on walnut and hickory, respectively. Ragonot (1893) discussed the species in detail and gave a coloured figure of the adult (he mentions only "*Alnus*" as the food plant, and elsewhere he treats as distinct the species previously confused by Packard).

Subsequent literature on *A. rubrifasciella* has provided, mainly, extensions in distribution for the species and information on its parasites. It has been reported from New Hampshire (Dimmock, 1898), New York City and Holly Beach, New York (Smith, 1910), Ottawa, Ontario (McDunnough, 1922), Sparrow Lake [near Orillia], Ontario (Viereck, 1926), Ithaca, New York (Leonard, 1928), Mt. Desert Island, Maine (Procter, 1938), and numerous stations in southern Ontario (Raizenne, 1952). Parasites have been recorded by Dimmock (1898), Ashmead (1900), Viereck (1926), and Raizenne (1952). A few notes on the adults and the larval case have been provided by Ely (1913), and Dyar (1908) and Forbes (1923) have remarked on their inability to distinguish between the adults of *A. rubrifasciella* and *A. comptoniella* in the absence of food plant data. Information on food plants indicates that the species has been erroneously reported on several occasions (Beutenmüller, 1889; Chittenden, 1903; Patch, 1908; Johannsen, 1910).

#### Life-History Notes

There is one generation of this species a year. The small larvae, which have spent the winter in hibernacula, resume feeding on the appearance of new foliage in the spring. Each larva fashions for itself a slender, tubular case, silken-lined, and coated exteriorly with black pellets of excrement. The larva extends itself from the case to feed, and as it grows it enlarges the case by additions of silk and excrement around the open end. Often the case assumes a more or less convoluted form after the manner of a cornucopia. When fully grown, the larva closes the end of the case with additional silk and excrement, and pupates within.

In the Ottawa district, almost full-grown larvae may be found during the latter half of June. In 1945, the writer made collections of such larvae from June 20 to 26. In the laboratory these larvae were segregated in lots of about a dozen specimens each, and placed in shallow, glass-topped rearing tins. Each lot was supplied with fresh alder leaves every second day. Feeding gradually diminished, the larvae pupated and the moths commenced emerging on July 2, and emergence continued for approximately three weeks. The first parasites emerged on June 23 and the last on July 19.

When a number of each sex of the moths were obtained they were placed in a six-inch paper-lined rearing jar, which was kept in a semi-dark situation in

<sup>3</sup>Subsequently, material from this host was described by Hulst (1890) as a distinct species, under the name *Acrobasis comptoniella*.



the laboratory. Food was supplied in the form of chopped raisins, diluted with water, in a small vial with a cotton wick. Fresh twigs of alder, with leaves, were also placed in the jar. Mating took place freely, and in a few days the first eggs were laid. The eggs, which are just large enough (0.5 mm. x 0.35 mm.) to be seen conveniently without the aid of a lens, were deposited on the under-sides of the leaves, scattered in arrangement but most numerous next the midrib and along the principal veins. Each egg was fastened firmly to the surface of the leaf by its flattened lower surface. In outline the egg is irregularly oval, conforming somewhat with the space in which it is deposited. Its upper surface is convex, but somewhat uneven, often a little shrunken in appearance, and with fine reticulate sculpture. Newly laid eggs are pale creamy-yellow, with several (3-8) small pinkish dots scattered over the surface. After hatching, the whitish chorion persists on the surface of the leaf.

Exact incubation data were not obtained, but in the laboratory, eggs laid during four days commenced hatching five days after the first egg was laid, and hatching was completed eight days from the same date. The newly hatched larva is pale creamy-white, with a light-brownish head and prothoracic shield. The larvae move about freely, spinning a delicate silken web in which fragments of frass become entangled. They then congregate and feed gregariously beneath the web, which they soon fashion, with additional silk, into slender, flimsy tubes. After the first moult the larvae continue to feed and to enlarge and lengthen the tubes. Most of the feeding takes place on the under side of the leaf, but some groups of larvae become established on the upper side, and in either instance they consume the epidermis and most of the mesophyll, leaving only the epidermis on the opposite side intact. As summer advances, feeding diminishes and the larvae become quiescent in their tubes. Late in the summer the larvae leave the tubes and spin hibernacula in sheltered situations on the adjacent branches, where they pass the winter. (These hibernacula may be difficult to find in nature. In several hours' searching on October 15, 1953, in a stand of infested alder near Ottawa, Mr. C. D. F. Miller found three specimens).

The life-cycle and habits correspond, in general, with what is known of certain other species of *Acrobasis*, notably *A. juglandis* (LeB.) and *A. betulella* Hulst. The former has been described in some detail by Mozzette *et al.* (1940) and the latter by Daviault (1937).

#### Parasites

The following list of parasites is based on material reared by the writer, supplemented by records from other specimens contained in the Canadian National Collection. It also includes the species previously recorded in the literature, the majority being represented in the rearings.

Most of the species listed have been recorded from a number of hosts in addition to *A. rubrifasciella*. These may be ascertained by consulting the summaries given by Muesebeck *et al.* (1951) for the parasite species concerned. Among the species listed there are such economically important insects as the codling moth, the oriental fruit moth, and various others of the genera *Acrobasis*, *Laspeyresia*, *Mineola*, and *Tetralopha*. It thus appears that stands of alder infested by *A. rubrifasciella* may serve as a valuable reservoir for the maintenance of populations of certain parasites that are useful in the control of some common pests.

A noteworthy feature of the parasitism of this species is the apparent absence of dipterous parasites, none having been reared by the writer or reported by

previous workers (The scatopsid *Rhegmoclema atrata* Say, reported by Raizenne (1952), is not regarded as a parasite). A possible explanation lies in the fact that most collections of host material were made when the *rubrifasciella* larvae were in an advanced stage of development; thus dipterous parasites that may have reached larval maturity in the earlier-instar host larvae and then departed from their hosts to pupate would not be obtained.

#### BRACONIDAE

*Meteorus indagator* (Riley).—First reported from *A. rubrifasciella* by Raizenne (1952), but previously a well-known parasite of several other species of *Acrobasis* and related groups. Reared in the Ottawa district from *A. rubrifasciella* on several occasions as follows: ♂, June 15, 1943; ♂, 3 ♀ ♀, July 2-13, 1945; ♂, July 10, 1951; and at Bobcaygeon, Ontario: ♀, July 5, 1932.

*Meteorus niveitarsis* (Cress.).—One female at hand, reared from *A. rubrifasciella* from Blackburn, Ontario, July 18, 1951. This is a new host record.

*Macrocentrus instabilis* Mues.—Material at hand reared from *A. rubrifasciella* in the Ottawa district as follows: ♀, June 16, 1923; ♂, ♀, June 23, 29, 1945. This species has numerous hosts, including several other species of *Acrobasis*, but has not previously been recorded from *A. rubrifasciella*.

*Agathis calcaratus* (Cress.).—Apparently first reported as a parasite of *A. rubrifasciella* by Dimmock (1898) under the name *Microdus similimus* Cress. Subsequently recorded from the same host by Muesebeck and Walkley (in Muesebeck *et al.*, 1951) and by Raizenne (1952). Also reared in the Ottawa district, as follows: ♂, July 9, 1943; 5 ♂ ♂, 5 ♀ ♀, July 9-19, 1945.

*Apanteles* sp.—Material at hand reared from *A. rubrifasciella*: ♀, Bobcaygeon, Ontario, June 26, 1932; ♂, 3 ♀ ♀, Ottawa, Ontario, June 16-20, 1951. This species is easily distinguished from all the species of *Apanteles* that have previously been reported as parasites of various species of *Acrobasis*. The species apparently resembles *Apanteles canarsiae* Ashm. in many respects, but is probably distinct. Also, specimens from the Ottawa district were reared from *A. betulella* Hulst and *A. secundella* Ely.

*Phanerotoma tibialis* Hald.—A detailed taxonomic account of this species was given by Walley (1951). It has been reared in the Ottawa district from *A. rubrifasciella* in 1943, 1945, and 1951. Among the species here considered it is unique, in that it oviposits in the egg of the host. The parasite overwinters as a tiny larva within the young larva of the host, and completes its development and emerges as an adult the following summer. Adults from field-collected host material were reared as follows: 2 ♂ ♂, June 24, 1943; ♀, June 30, 1943; ♂, July 2, 2 ♀ ♀, July 6, 10, 1945; ♀, July 13, 1951. In the laboratory, an unmated female was confined with freshly laid host eggs and was observed to oviposit in them, almost immediately. A week later, *rubrifasciella* larvae that hatched from these eggs were dissected, and each contained a first-instar larva of the parasite. The latter, in general, resembles the larvae of *Ascogaster quadridentatus* Wesm. and *Chelonus annulipes* Wesm., as described by Rosenberg (1934) and Vance (1932), respectively. It agrees with these, in particular, in having the labium extended in the middle in the form of a short truncate process.

#### ICHNEUMONIDAE

*Scambus* sp.—Reported from Carleton Co., Ontario, by Raizenne (1952) as a parasite of *A. rubrifasciella*.

*Delomerista novita* (Cress.).—Dimmock (1898) reported the rearing of a specimen of this species from *A. rubrifasciella* in New Hampshire. Until verification is obtained, this record is considered questionable in view of the fact that species of the genus *Delomerista* are generally regarded as being parasites of the larvae of diprionine sawflies.

*Itopectis conquisitor* (Say).—Reported on one occasion as a parasite of *A. rubrifasciella*, by Raizenne (1952).

*Phytodietus burgessi* (Cress.).—Reported by Raizenne (1952), as a parasite of *A. rubrifasciella*. Ottawa rearings as follows: ♂, June 6, 2 ♀ ♀, July 9, 12, 1945.

*Phaeogenes phycidis* Ashm.—First reported from *A. rubrifasciella* by Dimmock (1898), and again recorded from this host by Raizenne (1952).

*Craticheumon quintilis* (Vier.).—Recorded by Ashmead (p. 566, 1900) under the name *Ichnemon nanus* Cress. as a parasite of *A. rubrifasciella* in New Jersey. The writer is not familiar with this species and has not been able to verify the record.

*Horogenes comptoniellae* (Vier.).—Originally described in 1926, in part from specimens reared from *A. rubrifasciella* at Sparrow Lake (near Orillia), Ontario. Again reported from this species by Raizenne (1952), and reared from the Ottawa district as follows: ♂, June 11, 1945; ♀, June 23, 1943; 2 ♀ ♀, July 5, 1951.

*Horogenes* sp.—This species differs considerably from the preceding. It resembles *H. kiebtani* (Vier.) closely, but is distinct from it, and appears to be undescribed. It is represented in the collections at hand by 10 specimens reared from *A. rubrifasciella* from Blackburn, Ontario: 5 ♂ ♂, 5 ♀ ♀, June 20-July 16, 1951.

*Anomalon exile* Prov.—Under this name Dimmock (1898) reported rearing a specimen from *A. rubrifasciella* in New Hampshire. This record has not been verified, but Townes and Townes (in Muesebeck et al., 1951) included *exile* among certain unplaced species of the Gravenhorstiina. Another species in this group, *Gravenhorstia acclerivorus* (Rohw.), has been recorded as a parasite of the sweetfern-feeder, *A. comptoniella* Hulst.

#### PERILAMPIDAE

*Perilampus fulvicornis* Ashm.—First reported as a parasite of *A. rubrifasciella* by Raizenne (1952). Reared from the same host from the Ottawa district as follows: 14 ♂ ♂, July 9-19, 1945; 10 ♂ ♂, ♀, July 13-24, 1951.

#### PTEROMALIDAE

*Habrocytus phycidis* Ashm.—Originally described by Ashmead (1898) from specimens reared by Dimmock (1898) from *A. rubrifasciella* in New Hampshire.

*Habrocytus thyridopterigis* How.—A single rearing of this species from *A. rubrifasciella* reported by Raizenne (1952).

#### Acknowledgments

The writer wishes to express his appreciation for assistance during this study from Mr. H. Raizenne, Forest Biology Division, Ottawa, for supplying records and material from the collections in his charge; from Dr. O. Peck of the Systematic Entomology Unit, for identifying specimens of the genus *Perilampus*; and from Mr. C. D. F. Miller, also of the Systematic Entomology Unit, for finding hibernacula of the host in the field in the Ottawa district.

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 Book Notice

**THE ORIGIN AND HISTORY OF THE BRITISH FAUNA**, by Bryan P. Beirne; pp. X and 164; 60 maps. Methuen & Co. Ltd., London. 1952. 18 shillings.

Dr. Beirne has written, and Methuen & Co. have produced, a most attractive and readable book. The material is mainly drawn from what has already been published in Dr. Beirne's considerable series of papers on the subject in various scientific journals, and the present work may be regarded as a synthesis and popularization of his views. The lucid text, is accompanied by a series of original maps; in both departments Dr. Beirne's talent for clear exposition is well shown.

In writing on a controversial topic an author is always faced with the choice of gaining clarity by emphasizing what seems to him the best interpretation or seeking impartiality by giving equal weight to all views. The latter course, though laudable in intent, is apt to result in confusion, and in this book Dr. Beirne has chosen the former. Though the product is, as I have indicated, a happy one, I fear that a false impression of certainty may in some places have been given to what actually must long remain highly debatable matter. However, Dr. Beirne's book is a most welcome summary of an important theory, and will be indispensable to students of the British fauna.

EUGENE MUNROE

**Humidity Reactions and Water Balance of Larvae of *Neodiprion americanus banksianae* Roh. and *N. lecontei* (Fitch)  
(Hymenoptera: Diprionidae)<sup>1</sup>**

By G. W. GREEN<sup>2</sup>

**Introduction**

This paper presents the results of bioclimatic investigations of two species of diprionid sawflies, *Neodiprion americanus banksianae* Roh. and *N. lecontei* (Fitch), important defoliators of pines in eastern North America. It deals primarily with the reactions of larvae of both species to gradients of evaporation rate.

Several methods of expressing atmospheric moisture for biological purposes have been employed by various authors. As saturation deficit and relative humidity are expressions of the moisture content of the air only, they were seldom used in this work. Instead, emphasis has been placed upon evaporation rate as a measure of stimulation by atmospheric moisture. The value of evaporation rate has been discussed thoroughly by Ramsay (9) and Thornthwaite (11), and by Wellington (12) in his work with larvae of *Choristoneura fumiferana* (Clem.).

**Materials and Methods**

The experimental insects used in most of these investigations were from the stock described earlier (5). Additional larvae, when required, were collected from field populations: larvae of *N. lecontei* from red pine near Blind River, Ontario, and larvae of *N. banksianae* from the site described earlier (5) and from Cloche Island, Ontario.

A single, bar type, evaporation-rate gradient was used in preliminary investigations. However, it was found that larvae of both species aggregated at the highest rate of evaporation that could be established with sulphuric acid solutions at room temperatures. Since this type of distribution was consistently adopted by larvae of both species and of all instars tested, it was thought that an end reaction was masking the true response to evaporation. Consequently, a new type of gradient was constructed.

Although end reactions are eliminated for the most part in concentric gradients, it is more difficult to make rapid observations of insect distributions in this type than in a linear gradient. Hence, a modification of the latter was developed, which proved well suited to the insects used in this work. Since larvae aggregate in the driest available regions, the simplest method of modifying a linear gradient to eliminate end reactions is to establish a double gradient of evaporation rates, with high rates of evaporation in the centre of the apparatus and lower rates at either end. This apparatus, with the gradient of evaporation rates developed and maintained in it, is shown in Fig. 1. It was constructed of  $\frac{3}{8}$  inch plywood and consisted of a floored box, 31 by 5 by 1 inches, into which was placed a series of eight petri-dish bases containing appropriate sulphuric acid solutions (cf. Wilson, 15). (This box is hereafter referred to as the *acid box*.) A second, floorless box, the *reaction chamber*, fitted the top of the acid box snugly. The chamber had a flange off each longitudinal wall leaving a 2-inch opening over the acid box. A nylon mesh floor was stapled across the bottom of this opening. One of the vertical walls, which were 1 inch high, had a series

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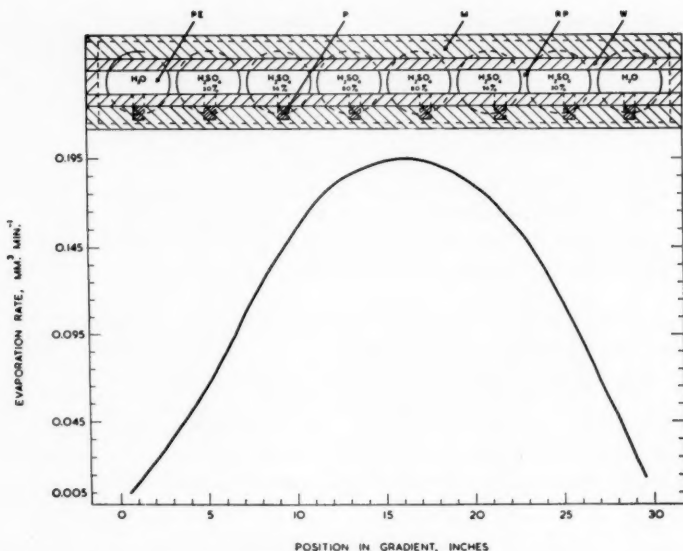


Fig. 1. Plan of the apparatus in which gradients of evaporation rates were established, and a representative curve of the evaporation rates. M- flange in reaction chamber to reduce width of platform over acid; P- port in reaction chamber wall; PE- petri plate base containing sulphuric acid solution; RP- reaction platform of fine nylon mesh, and W- wall of the reaction chamber.

of evenly spaced ports in it which were stoppered with removable wooden plugs. The top consisted of a sheet of plate glass scribed with cross lines at 1-inch intervals. This top rested upon a heavy paper gasket cut to fit the top of the walls.

The apparatus was fastened together with wire clamps running from the glass top of the reaction chamber to the base of the acid box. Lanolin was applied as a seal to the joint between the two halves of the apparatus. Twin fluorescent lamps were mounted approximately 24 inches above, and parallel to, the top of the reaction chamber, since it was found that larvae took up a final distribution in the gradient much more quickly in the light than in the dark. With the lamps in this position, the intensity of the incident light on the top of the chamber was approximately 200 foot-candles. Before any test, readings were taken with a "Weston" exposure-meter, and the apparatus was shifted until no light-intensity gradient could be detected along its length.

Preliminary tests showed that if larvae were exposed to constant moisture conditions before introduction into the apparatus, the results obtained were much more uniform than when they were introduced directly after removal from feeding clusters. This point has been brought out by Wellington (13), and, although the differences due to the acclimation period were not so marked in *Neodiprion* as they were in *Choristoneura*, they were sufficient to warrant its incorporation in the technique. Consequently, before introduction into the apparatus, larvae were exposed to dry air over anhydrous calcium chloride for four hours at room temperature.



After the four-hour acclimation period, 60 larvae of the required instar were introduced into the apparatus through the ports in the side of the reaction chamber, so that they were evenly spaced along its length. They were left undisturbed in the gradient for two hours. During the third hour, their positions in the gradient were recorded at ten-minute intervals.

At first, readings were taken with wet and dry thermocouples through the ports in the side of the reaction chamber at the beginning and end of each experiment. It was found that the presence of larvae in the chamber did not appreciably alter the gradient after three hours, so that, in subsequent tests, readings were taken only at the end of each experiment. The relative humidity values so obtained were converted into evaporation rates by means of the alignment chart illustrated in Fig. 2 (Wellington, unpublished data). A gradient graph was drawn with evaporation rate along the ordinate and distance from a fixed point along the abscissa. Using this graph, the reaction chamber was divided into zones of evaporation rate, and the number of larvae per zone was

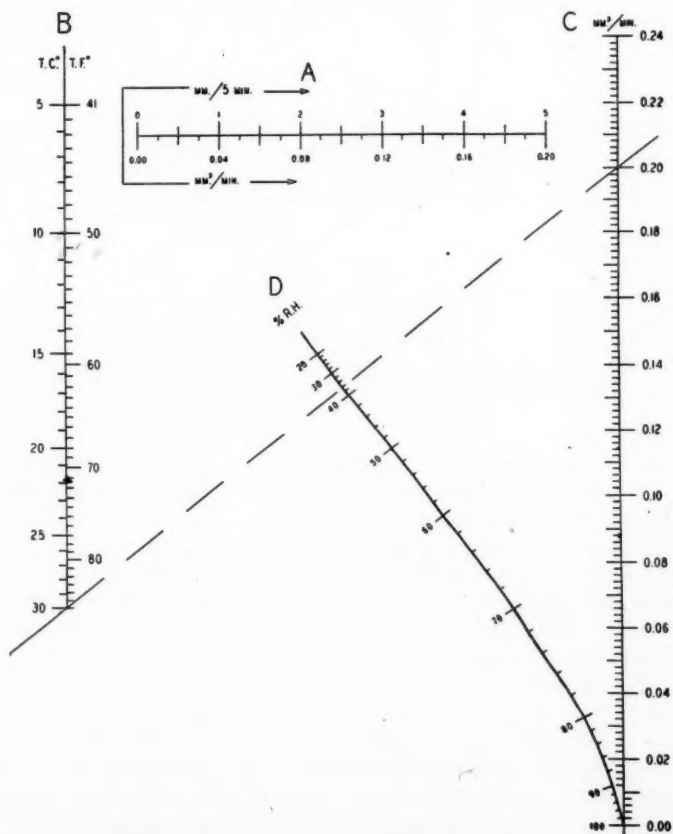


Fig. 2. Alignment chart used to convert thermoelectric relative humidity measurements made within the gradient to evaporation rates in still air. (After Wellington, unpublished data).

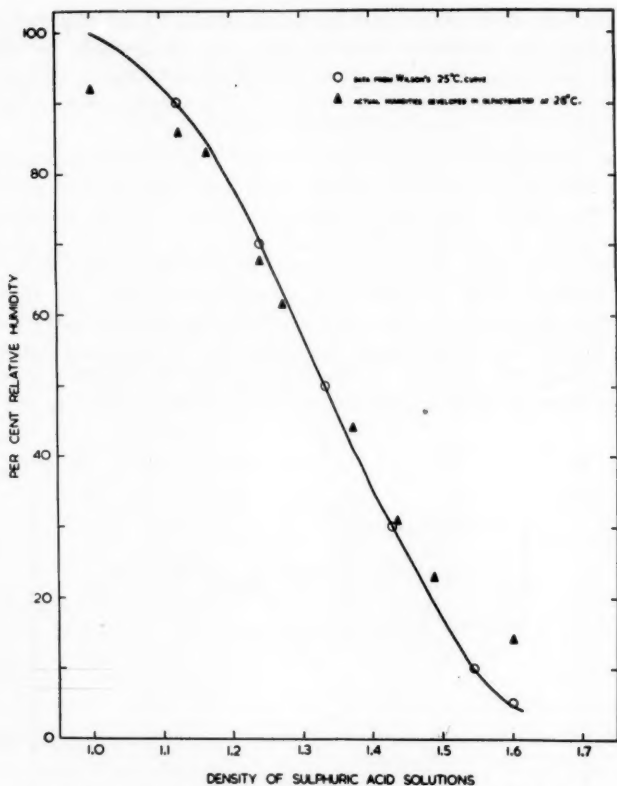


Fig. 3. Relative humidities developed with sulphuric acid solutions in the olfactometer compared with the critical compilations of Wilson (1921).

calculated from the sum of the observations of larval positions during their third hour of exposure to gradient conditions. From these data, frequency distributions along the gradient were calculated and plotted.

In still air, the maximum rate of evaporation possible with sulphuric acid solutions was  $0.195 \text{ mm.}^3 \text{ min.}^{-1}$ . Consequently, to produce higher rates of evaporation, an olfactometer was constructed as designed by Willis and Roth (14). The only major difference in design was the substitution of a rectangular insect cage and influent ports for the right cylindrical construction used by these authors. This modification eliminated the neutral zone in the centre of the cage, which contained 12% of the insects in their tests. Using the rectangular cage and ports, 100% participation was obtainable in any of the tests. Good partitioning did not occur in this apparatus with 1 litre per minute flow of each air stream, but, when this was increased to 2 litres per minute, tests with ammonium chloride smoke indicated extremely good partitioning, with little or no mixing at the boundary. Air flow at this rate consistently produced relative humidities at  $28^\circ\text{C.}$  that agreed closely (Fig. 3) with data presented by Wilson (15), except at the upper and lower limits of the humidity range.

The index of the humidity reaction was calculated from the formula  $100 (D-W)/N$ , where D is the sum of the positions occupied by the insects in the drier choice, W the sum of the positions in the moister, and N the total number of positions per choice (Bentley, 2). Ten insects were used in each test. They were left undisturbed for a five-minute period at the beginning of each experiment, and then ten observations were made of their positions in the chamber at one-minute intervals.

### Results

First-instar larvae were not tested in any of these experiments. At room temperature and when fully fed, this instar is at best sluggish, and final distributions in gradients are difficult to obtain. Hence, the following results apply to larvae beyond the first instar.

The distributions obtained for larvae of *N. banksianae* exposed to the double evaporation-rate gradient are presented in Fig. 4. All instars tested were quite

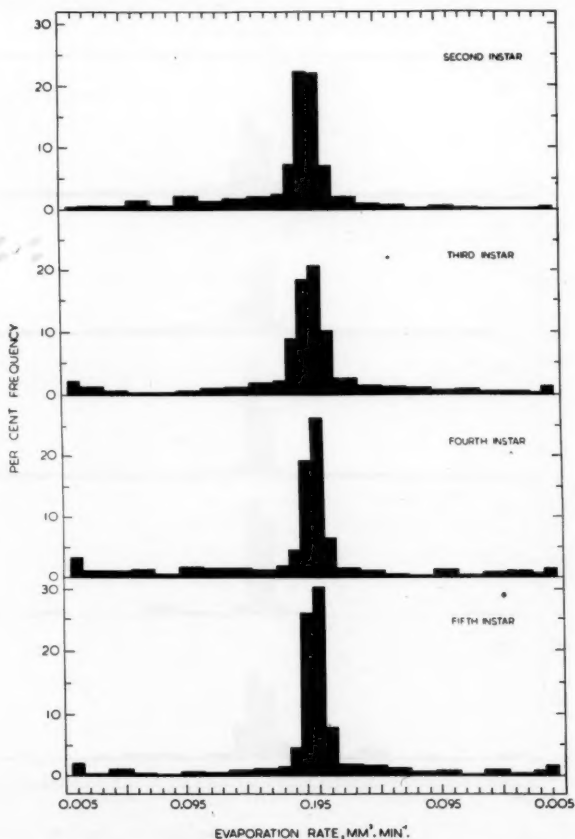


Fig. 4. Inter-instar comparison of the ranges of evaporation rates in which *N. banksianae* larvae of Instars II to V inclusive, aggregated during their third hour of exposure to the double evaporation rate gradient.

similar in their selection of the drier parts of the apparatus but, as the larvae grew older, their selection of the drier regions became progressively stronger.

Larvae of *N. lecontei* were tested in the same apparatus, with the results shown in Fig. 5. These results are quite similar to those obtained for *N. banksianae*. Again, with later instars, increasing preference for the drier parts of the gradient is evident, the only noticeable difference between the two species being a slightly stronger selection of the drier regions by *N. lecontei*. (It should be mentioned here that only 40 sixth-instar larvae of *N. lecontei* were tested, because virus disease appeared in the experimental stock. However, other observations suggest that this instar would have demonstrated an even stronger selection of the drier parts of the gradient than any of the other instars tested.)

While in the gradient, larvae were constantly in motion, moving back and forth along the length of the reaction chamber. When numbers of larvae were observed together, no noticeable difference in speed of motion could be detected as they moved from zone to zone. The general appearance of the group reaction suggested extensive milling in the centre of the gradient but no definite conclu-

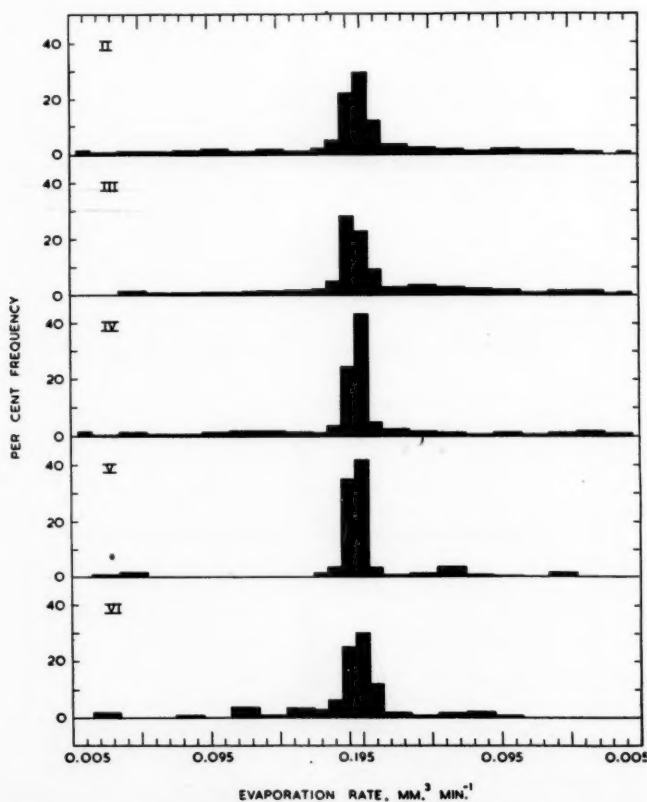


Fig. 5. Inter-instar comparison of the ranges of evaporation rates in which *N. lecontei* larvae of instars II to VI inclusive aggregated during their third hour of exposure to the double evaporation rate gradient.

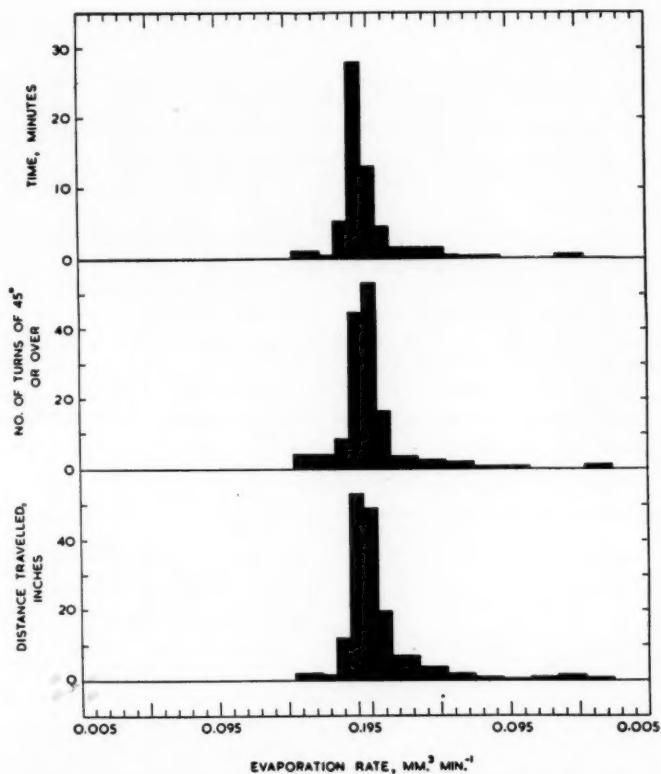


Fig. 6. Quantitative expression of the tracks made by a fourth-instar larvae of *N. lecontei* during 92 minutes in the double evaporation rate gradient.

sions could be reached concerning the mechanism that maintained the bulk of the population in the central zone.

To study the mechanism of the reaction to gradient conditions, a single fourth-instar larva of *N. lecontei* was placed in the gradient after the usual acclimation period. Its course within the gradient was charted for the next 92 minutes. Checks were made on the larva's path at one-minute intervals. The distance travelled was measured with a planimeter from the tracing of its movements. The information gained from this experiment is shown in Fig. 6. This figure shows that the larva spent more time in the preferred zone (Fig. 5) than in any other. It made more turns of  $45^\circ$  or more in the preferred region, and travelled farther there, than in any other region. Simple calculations from these data show that the animal's velocity was slightly lower in the preferred zone than in any other and that the number of turns per unit distance was much greater in the preferred zone and the zones immediately adjacent to it than in any other part of the gradient. Thus, while a decrease in velocity does contribute to the formation of aggregations in the central reaches of the gradient, increased turning in these regions seems to be the primary cause.

Since observations of group behaviour of both species showed that they aggregated in the preferred regions by virtually the same mechanism, observa-

tions on the response mechanism were not extended to include larvae of *N. banksianae*.

Still air within the gradient apparatus limited the highest rate of evaporation that could be established and maintained. Since larvae of both species consistently chose the driest parts of the gradient and maintained peak distributions there until death, other experiments were carried out in the olfactometer described earlier in an attempt to find an upper limit to the range of evaporation rates that these larvae tolerated.

The results obtained when larvae were presented with graded choices of humidity in the olfactometer are presented in Table I. It will be remembered that the indices of reaction in these tests are calculated from the formula  $100(D-W)/N$  described earlier in the text. This table also shows the minimal rates of evaporation that could be expected at the temperatures and humidities tested. These rates are calculated from the alignment charge (Fig. 2) and are clearly too low, since air movement could not be considered. They are included so that a rough comparison of the results of gradient and paired-choice experiments may be made.

TABLE I  
Reactions of larvae of *N. lecontei* when exposed to alternative humidity choices within an olfactometer at 28° C.

Alternative humidity choice	Range of index of reaction		Number of tests in each instar	Minimum evap. rate choice (mm. <sup>3</sup> min. <sup>-1</sup> )	
	Instar IV	Instar VI			
A	90 vs. 10	85.0 ± 5.0	83.0 ± 9.0	2	0.010 vs. 0.240
	70 vs. 10	78.5 ± 2.5	83.0 ± 9.0	2	0.064 vs. 0.240
	50 vs. 10	1.5 ± 5.5	68.0 ± 14.0	2	0.142 vs. 0.240
	30 vs. 10	20.0 ± 3.0	4.0 ± 4.0	2	0.206 vs. 0.240
B	90 vs. 30	85.0 ± 7.0	100.0 ± 0.0	2	0.010 vs. 0.206
	70 vs. 30	70.5 ± 12.5	71.0 ± 9.0	2	0.064 vs. 0.206
	50 vs. 30	20.0 ± 16.0	60.0 ± 8.0	2	0.142 vs. 0.206
C	90 vs. 50	54.0 ± 13.0	97.0 ± 1.0	2	0.010 vs. 0.142
	70 vs. 50	61.5 ± 13.5	86.0 ± 4.0	2	0.062 vs. 0.142

Section A of Table I shows the results obtained when the dry side of the apparatus was maintained at 10% R.H. and the moist side varied between 90 and 30%. In general, the intensity of the dry reaction decreases as progressively lower humidities are paired with 10%. This is usually the case when other combinations of humidity are tested (sections B and C). The results obtained with sixth-instar larvae of *N. lecontei* are the more consistent and indicate that no less than 10% R.H. at 28°C. (or an evaporation rate of certainly no less than 0.240 mm.<sup>3</sup> min.<sup>-1</sup>) is the upper limit of the preferred zone of this instar of the species. The results of fourth-instar larvae of *N. lecontei* suggest that the upper limit may be somewhat lower for this instar (cf. Section A—50 vs. 10% R.H., and Section B—50 vs. 30% R.H.) in accordance with the increasing degree of selection of the higher rates of evaporation shown by larvae of *N. lecontei* as they grow older (Fig. 5).



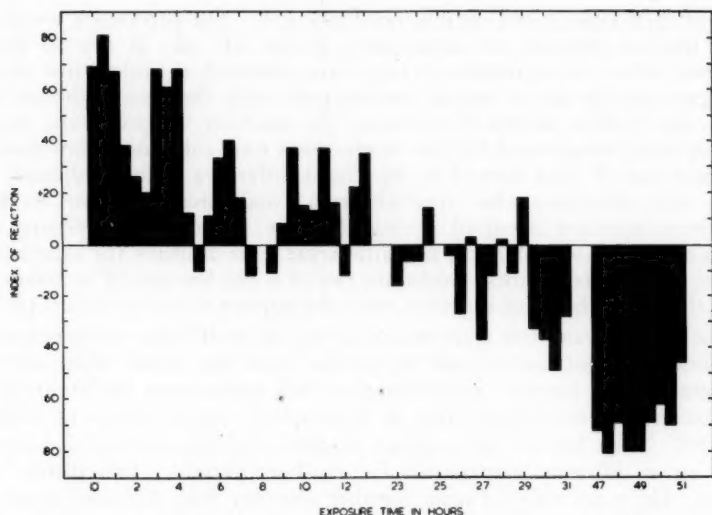


Fig. 7. Progressive changes in the index of reaction of fourth-instar larvae of *N. banksianae* exposed to a choice between 10 and 90% R.H. in the olfactometer for a prolonged period. A positive index of reaction indicates movement to the dry side of the apparatus; a negative value, movement to the moist side.

It was mentioned earlier that larvae of both sawflies maintained their distributions in the double gradient until death. Under conditions other than those in the gradient, it seemed possible that, as desiccation progressed, larvae might move to more moderate zones, where evaporation of water from their bodies would not proceed at such a rapid rate. The olfactometer was used to test this, since larvae in it could be exposed to either very moist or very dry air. Fourth-instar larvae of *N. banksianae* were used. After the regular acclimation period, 10 larvae were placed in the olfactometer and were offered a choice between 90 and 10% R.H. at 28°C. Their positions in the apparatus were observed every half-hour at intervals over successive days. The results obtained are presented in Fig. 7.

After the larvae had been in the apparatus for nearly two hours, more shifts to the moister side became evident. Thus, the relatively static distributions indicated by short-term exposures (Table I) failed to hold after one or more hours exposure to dry air. In fact, the distributions were quite dynamic, as may be seen from an examination of Fig. 7. Fluctuations between the dry and the moist sides of the apparatus continued, and the selection of the moist side became increasingly stronger with time until, after 47 hours exposure, the index of reaction shifted definitely and permanently to the moist side of the chamber. Further exposure did not result in a shift in sign of the reaction and, after 51 hours of exposure, many of the larvae were moribund, and movements were slow and sluggish.

To determine the amount of body water lost during exposure of soft-skinned larvae to dry air, groups of 10 fifth-instar larvae of *N. banksianae* were placed in desiccators over anhydrous calcium chloride or over water. These groups were weighed before they were placed in the desiccators and again at intervals during their exposure. Any frass that was deposited was included in the weights. The

results of these experiments are illustrated in Fig. 8. The percentage weight-loss at any level of exposure was significantly greater (F test) in dry air than in moist but, when the regressions in Fig. 8 are examined, it is clear that after 10 hours exposure the rate of water loss was practically the same in dry air as in moist. For further statistical treatment, the ten-hour weights were assumed to be the initial weights and further weight losses were calculated from these. A covariance test (F test) showed no significant difference in these adjusted data. Hence, any difference that resulted from conditioning at two levels of atmospheric moisture occurred during the first 10 hours of exposure only. (When this fact was established, no more larvae were available for experimentation but, as indicated by these results, the rate of water loss should be determined during the first 10 hours of exposure, since this appears to be the critical period.)

The rate of water loss from insects in dry air at different temperatures has been shown by many authors, and the broken curve that results when such data are plotted is well known. Experiments of this nature were performed in the olfactometer with fifth-instar larvae of *N. lecontei*. Again, groups of 10 larvae were used. These larvae were weighed, placed in the olfactometer, and exposed to dry air at different temperatures for one-hour periods. Immediately after exposure, they were weighed again together with any frass deposited during the experiment. Weight loss was considered to be due to the evaporation of water from the animals.

The results are shown in Fig. 9. The rate of water loss increases but slightly with temperature up to approximately 40°C. Beyond this temperature, the rate increases very rapidly, with the result that two regression lines fit the data closely.

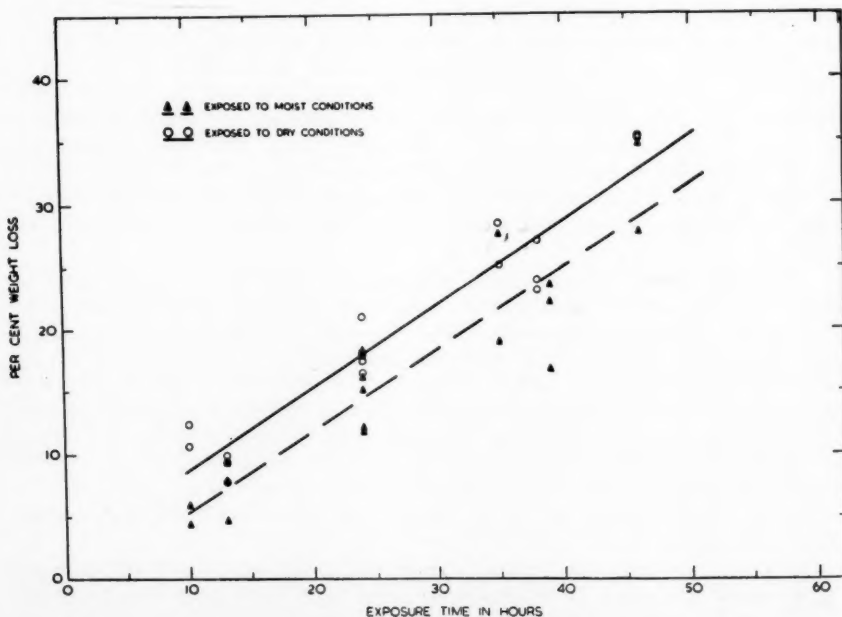


Fig. 8. Regression of weight loss by evaporation on time for fifth-instar larvae of *N. banksianae* starved over anhydrous calcium chloride or over water in desiccators.

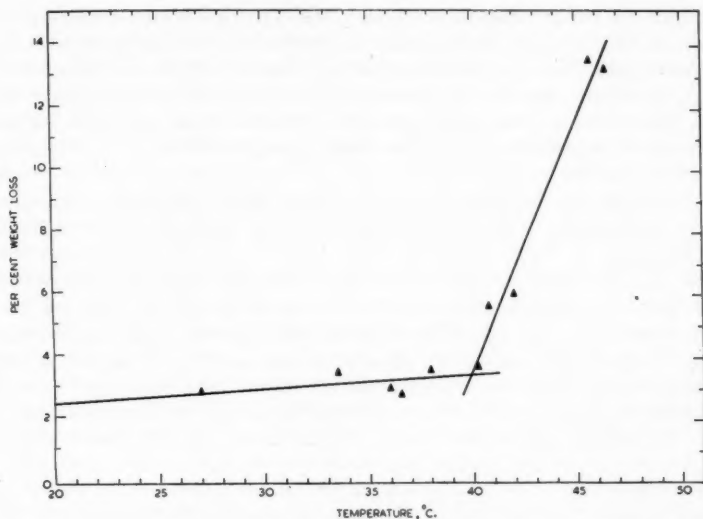


Fig. 9. Water loss from fifth-instar larvae of *N. lecontei* exposed to slowly moving dry air for periods of one hour at different temperatures. (Straight lines through the points fitted by method of least squares).

The point of intersection of these lines is seen to lie very close to 40°C., slightly below the mean photic reversal temperature of larvae of this instar (5).

#### Discussion

When offered gradients or paired choices of atmospheric moisture at constant temperatures, larvae of *N. banksianae* and *N. lecontei* consistently choose the driest regions available to them. In an illuminated gradient, larvae aggregate in the dry regions by making more turns in a unit interval. This primary mechanism is augmented by a slight reduction in speed of movement while in the preferred zone. Consequently, the reaction in a gradient of evaporation rates is primarily klinokinetic and secondarily orthokinetic (4). On the other hand, larvae exposed to paired choices of atmospheric moisture within an olfactometer maintain their distributions on the dry side of the apparatus primarily by means of an orthokinetic mechanism (4). Under olfactometer conditions, larvae often remain motionless for long periods of time in the dry side of the apparatus, but are almost always in motion when on the wet side. This difference in response seems to be associated with different light conditions during the two types of experiments. In the gradient, larvae were strongly illuminated by an overhead source of diffuse light, which induced continual movement. Experiments in the olfactometer were performed in the dark and, consequently, the larvae were less active.

Larvae of both species and of all instars tested aggregated in the areas of highest evaporation provided in the gradient. Thus, the peaks of their distributions stood at the highest rate of evaporation available and, as indicated by olfactometer experiments, the peak could have been as high as  $0.240 \text{ mm.}^3 \text{ min.}^{-1}$  for sixth-instar larvae of *N. lecontei* at least.

Within the limits of the physical environment of any one tree, conditions are influenced greatly by surrounding growth. Thus, a tree which is growing

in the open, or on the fringe of a stand, is subject to a more extreme environment, at least in factors such as temperature, humidity, air movement, and hence evaporation rate, than is a shaded or partially shaded tree of the same species. In general, about any one tree, evaporation rate is greatest about its periphery and should extend in an increasing gradient upwards from the soil surface, the ultimate level reached by this factor being greatly influenced by the degree of exposure of the tree.

Considering the preference shown by larvae of *N. banksianae* and *N. lecontei* for dry regions, one would expect, first, to find them on the most open and exposed regions of their individual hosts and, second, that host trees would be selected on the basis of their exposure. Indeed, eggs of both species are commonly found near the ends of branches on the previous year's foliage. The second supposition is supported by Forest Insect Survey reports. When Forest Biology Rangers make collections of insects, they record the degree of exposure of the host as: (a) Shaded—nearly completely shaded by overstory or by members of the same stand; (b) Partially shaded—partly shaded by adjacent trees in the stand; (c) Fringe—exposed trees along lake shores or streams, or on the edge of forest stands, or on the edge of openings in the forest stand; and (d) Open. Survey records of larval collections of *N. banksianae* and *N. lecontei* were examined for the years 1952 and 1953 and the results are tabulated in Table II. For present purposes, fringe and open exposures were grouped, since they are essentially the same.

In both species the majority of the collections were made from trees with open and fringe-type exposures. The selection of exposed hosts is statistically stronger ( $2 \times 3$  contingency) in *N. lecontei* than in *N. banksianae* in accordance with the stronger selection by larvae of *N. lecontei* of the drier reaches of the evaporation rate gradient (Figs. 4 and 5).

Many insects (e.g. *Blatta orientalis* L. (6), *Tribolium castaneum* (Hbst.) (14), *Ptinus tectus* Boie (2) and *Choristoneura fumiferana* (Clem.) (13)), while normally preferring relatively dry air, reverse their reactions and show a decided preference for moist air when they are desiccated. For example, Wellington (13) has demonstrated that the apparently stable distribution of normal spruce budworm larvae in a gradient of evaporation rates soon breaks down and that a multimodal distribution occurs after one to three hours of exposure. Prolonged exposure to gradient conditions results once more in the establishment of a final, stable distribution with its peak at a much lower rate of evaporation than the first. No such results were obtained with the *Neodiprion* species tested in the

TABLE II  
Exposures of host trees from which collections of larval colonies of *N. banksianae* and *N. lecontei* were made in Northern Ontario during 1952 and 1953.

Species	Number of Collections			
	<i>N. banksianae</i>		<i>N. lecontei</i>	
Year.....	1952	1953	1952	1953
Shaded.....	1	3	0	0
Partially shaded.....	12	53	5	14
Open and Fringe.....	33	93	72	189

double evaporation-rate gradient. These larvae maintained their distributions in the driest regions afforded by the gradient until death. However, when fourth-instar larvae of *N. banksianae* were exposed in the olfactometer to a choice between 90 and 10% R.H. at 28°C., the initially strong dry reaction began to break down after about one hour and periods were spent in the moister side of the apparatus. These shifts to the moist side became more marked with time until, by 47 hours, the reaction was very strongly in favour of the moist side of the apparatus. Thus, sawfly larvae also are able to move to an area of less stress provided that the gradient between the different zones of atmospheric moisture is sufficiently steep.

Weight loss by sawfly larvae exposed to dry or moist air at moderate temperatures appears to be a function of the dryness of the air during the first 10 hours of exposure. After this period, the rate of weight loss becomes practically the same in dry and in moist air. This suggests that some control over water loss is exercised by the insects, presumably after a certain depression in the body-water level is reached. Since most of the water lost by evaporation from insects takes place through the spiracles (7), control is presumably through the tracheal system. This may take place either by direct spiracular control (7) or through a limitation exerted by the diffusion of water through the tracheal walls (8). It is evident that further experimentation along these lines is needed, and that attention should be directed to the effects of short-term exposures to extreme conditions.

It is interesting to note that the temperature at which a sudden increase in the rate of water loss from fifth-instar larvae of *N. lecontei* occurs corresponds quite closely to the mean photic reversal temperature (5) for this instar. Since light-reversal reactions normally take animals to sites where stress imposed by physical factors is less extreme, their occurrence here seems to have a definite survival value. If reversal reactions have any survival value, it would be expected that they should occur before temperatures approach too closely to a lethal level. The close association of the level of reversal temperature in the fifth instar and the temperature at which a tremendous increase in water loss in dry air begins (presumably due to a change in state of cuticular waxes (10)) lends some weight to this argument.

#### Summary

1. Larvae of *N. banksianae* and *N. lecontei* react to gradients of evaporation rate by aggregating at rates as high as  $0.195 \text{ mm.}^3 \text{ min.}^{-1}$ , with indications that sixth-instar larvae of *N. lecontei*, at least, would show a preference near  $0.240 \text{ mm.}^3 \text{ min.}^{-1}$  if this rate had been presented to them in gradient form. Aggregations in an illuminated gradient are produced primarily by a klinokinetic mechanism.

2. Larvae of both species demonstrate a strong dry reaction upon initial exposure to paired humidity-choices within an olfactometer at 28°C. It has been shown that distributions that appear to be static at first become quite dynamic as exposure is prolonged, and that, in time, a decided wet reaction occurs. Aggregations in chambers where paired humidity-choices are presented are produced orthokinetically.

3. The preference for regions of high evaporation rates, as indicated by laboratory experiments, is reflected in the distribution of both species on their hosts, and also in the selection of host trees on the basis of their exposure. Both species are normally found in the most exposed sites on the host and there is

evidence that open-grown, stand-border trees are the most susceptible to attack, especially by larvae of *N. lecontei*.

4. There is evidence to suggest that some tracheal control over the rate of water loss occurs in larvae of *N. banksianae* when they are starved in dry air. Although weight losses due to the evaporation of body water from these larvae are greatest when they are exposed to dry air, the rate of water loss becomes the same in dry and in moist air after 10 hours of exposure.

5. Fifth-instar larvae of *N. lecontei* begin to lose body water at a much more rapid rate in dry air at temperatures near 40°C. This temperature corresponds closely to the mean light-reversal temperature of this instar.

#### Acknowledgments

The criticism and advice offered by M. L. Prebble, R. M. Belyea and members of the staff of the Forest Insect Laboratory, Sault Ste. Marie, Ontario, is gratefully acknowledged. I am particularly indebted to W. G. Wellington for his help and supervision during the course of these investigations. Technical assistance in the laboratory was provided by Miss P. M. G. West.

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**The Male of *Ixodes signatus* Birula  
(Acarina: Ixodidae)<sup>1</sup>**

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***Ixodes signatus* Birula**

*Ixodes signatus* Birula, 1895, pp. 357-358, Pl. 1, Figs. 10-13.

*Ixodes arcticus* Osborn, 1899, p. 553. Synonym, *vide* Cooley and Kohls, 1945, p. 201.

*Ixodes parvirostris* Neumann, 1901, p. 284. Synonym, *vide* Banks, 1908, p. 21, and Nuttall *et al.*, 1911, p. 261.

*Ixodes eudypidis* var. *signata* [Birula], Neumann, 1904, p. 451. Synonym, *vide* Nuttall *et al.*, 1911, p. 261.

*Ceratixodes signatus* (Birula), Banks, 1908, p. 21, Pl. II, Figs. 1-3.

The types of Birula (♀, N, and L) came from Unalaska, Aleutian Islands. The female, nymph, and larva were redescribed by Nuttall *et al.* (1911) from the above material and specimens from Brandt's cormorant, *Phalacrocorax penicillatus* (Brandt), from Pacific Grove, California. The female and nymph were again described by Cooley and Kohls (1945). The male of the species is herewith described for the first time.

**Body.**—Unusually long; length, 3.0 mm. (to tip of scapula); width, 1.53 mm. Marginal fold of preserved specimen pale yellow-brown; scutum, legs, and capitulum darker.

**Capitulum.**—Basis widest, 0.32 mm., immediately behind the palps, with lateral margins and neck converging posteriorly. Dorsal surface punctate, posterior edge slightly sinuous, postero-lateral corners rounded and obtuse. Cornua absent. Palpi broadly attached to basis, and short, with numerous stout spines. Article 1 distinct; articulation between articles 2 and 3 obscure. Article 3 spatulate and reflexed, with an inner distal flange and two stout distal spines. Ventrally the basis is broad, smooth, and shiny, with a faint transverse groove. Auriculae absent. Palpal article 4 about halfway back on article 3.

**Hypostome.**—Truncate, with tip slightly depressed. Denticles faint, 1/1, about four per file.

**Scutum.**—Oblong, with lateral margins nearly parallel. Punctations numerous over posterior two-thirds, hairs sparse and short. Scapulae small and rounded. Cervical grooves shallow, lateral carinae faint, lateral fold and groove prominent.

**Ventral Plates.**—Impunctate anteriorly, becoming increasingly punctate toward the posterior margin, where the pits are confluent and heavily sclerotized. Anal plate clearly marked by anal groove, but demarcation of median and adanal indistinct. Genital aperture to anal groove, 1.77 mm.; anal plate, 0.85 mm. long.

**Legs.**—Coxae similar to those of the female; internal spurs absent but external spurs distinct and about as long as broad, that on coxa II being largest. Legs spiny; outer surfaces of metatarsi with two rows of 6-8 spines. Tarsus I, 0.39 mm. long; tarsus IV, 0.35 mm.; metatarsus IV, 0.35 mm.

**Spiracular Plate.**—Subcircular; 0.32 mm. x 0.25 mm.; goblets numerous and uniform; macula situated anteriorly.

**Genital Aperture.**—Slightly posterior to the antero-proximal corners of coxae II.

<sup>1</sup>Contribution No. 3177, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada; presented at the third annual meeting of the Entomological Society of Canada, Victoria, British Columbia, October 19, 20, and 21, 1953.

<sup>2</sup>Officer-in-Charge.

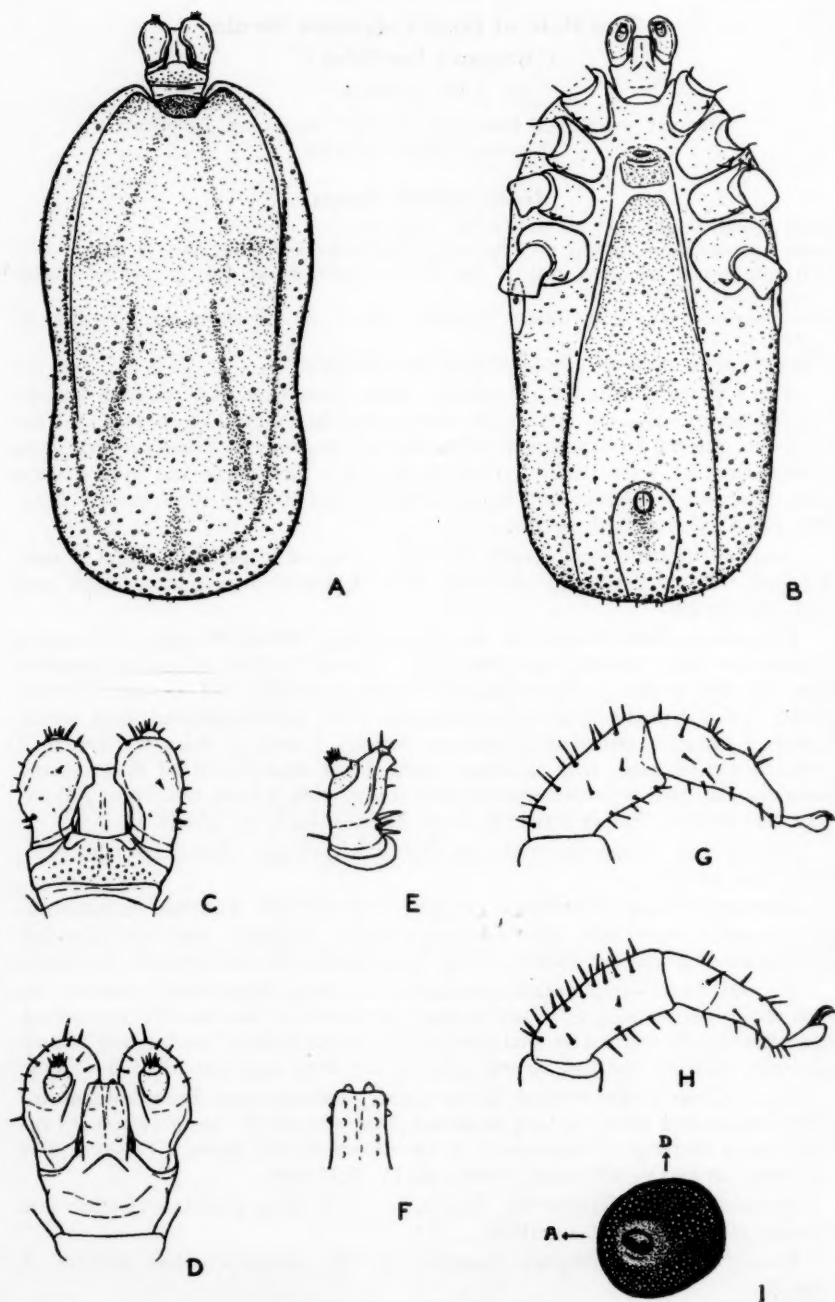


Fig. 1. *Ixodes signatus* Birula, male. A, Dorsal view. B, Ventral view. C, Capitulum (dorsal). D, Capitulum (ventral). E, Palpus (lateral). F, Hypostome. G, Metatarsus and tarsus, leg I. H, Metatarsus and tarsus, leg IV. I, Spiracle.

TABLE I

Records of the tick *Ixodes signatus* at the Entomology Laboratory, Kamloops, B.C.

Accession Number	Locality	Date	Host	Number and Sex	Collector
707	Tofino, Vancouver Is., B.C.	5.VIII.26	Cormorant, <i>Phalacrocorax</i> sp.	2 ♀, 22N	Spencer
1519	Gull Is. (Howe Sound), B.C.	4.VII.39	" " "	4N, 1L	Gregson and Holland
2980	St. George Is., Pribilof Is. Alaska	26.VII.46	" " "	17 ♀, 1N	Carl
2976	Langara Is., Queen Charlotte Is., B.C.	8.VI.46	" " "	3 ♀	Carl
2979	St. Paul Is., Pribilof Is., Alaska	1.VII.46	Guillemot, <i>Uria</i> sp.	3N	Carl
3541	Pribilof Is., Alaska	10.VII.49	Rosy finch, <i>Leucosticte</i> sp.	3 ♀, N, L	Carl

The above description is of a male that was reared at Kamloops from the progeny of a partially engorged female (No. 1856) collected by Dr. Ian McTaggart Cowan from Baird's cormorant, *Phalacrocorax pelagicus resplendens* Audubon, January 25, 1941, Cowichan Bay, Vancouver Island, B.C. This male, along with its cast nymphal skin, and four nymphs that were collected from the original host have been deposited in the Canadian National Collection, Ottawa. The intervening laboratory host was a domestic goose.

This species of tick occurs mainly on marine birds along the Pacific coast from California to Alaska. Other records at the Kamloops laboratory are given in Table I. The unarmed hypostome suggests that the males of this species, like those of another marine bird tick, *Ixodes uriae* White, may not attach to their hosts but only inhabit their nests. Besides the vestigial nature of their hypostomes, the males of these two species also bear certain similarity in the unusual morphology of their palps.

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## A Key to the Females of *Tenthredo* of the Canadian Prairies. (Hymenoptera, Tenthredinidae).

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In certain years, adult sawflies constitute a conspicuous feature of the insect fauna which rests on foliage or visits flowers on the Canadian prairies and in neighbouring woodlands.

The most intense "outbreak" of these insects observed by the writer occurred in 1929 when they were by far the most conspicuous representatives of the insect fauna near Gull Lake, Alberta. In that year, in less than two weeks during early June, 53 species were taken in an area of about a half-mile square.

Less intense outbreaks are not uncommon locally. Though these usually include representatives of several genera, species that approximate  $\frac{1}{2}$ " in length and are comparatively slender in build with the sides of the body more or less parallel are the most subject to a temporary increase in numbers. All resemble, superficially, species of the genus *Tenthredo*.

In Alberta, the genera included in this complex are separable as follows:—

- |  |                     |
|--|---------------------|
| 1. Second anal cell centrally contracted.....  | <i>Macremphytus</i> |
| Second anal cell NOT centrally contracted.....   | 2                   |
| 2. Head broader at antennal bases than eye-height.....   | <i>Rbogogastera</i> |
| Head narrower at antennal bases than eye-height.....   | 3                   |
| 3. Antennal sockets NOT dilated. Hind-coxae more than twice as long as mid-coxae.....                    | <i>Macrophya</i>    |
| Inner margins of antennal sockets dilated and scale-like. Hind coxae NOT twice as long as mid-coxae..... | <i>Tenthredo</i>    |

The similarly shaped, though smaller, Emphytinae, in which the second anal cell is contracted, and the usually red-and-black Dolerinae<sup>1</sup>, in which the body surface typically is rugulose and the second and third submarginal cells are confluent, are not likely to be confused with this complex. The latter abound where the plant *Equisetum* flourishes.

*Macremphytus* is represented locally by *loveti* MacG. and *varianus* Nort. Though this genus is not very closely related to the others here included, both species bear a superficial resemblance to them. In both, the apices of the antennae and all of the tarsi are dull white, characters which do not occur in any locally captured species of *Tenthredo*.

*Rbogogastera* is represented by *californica* Nort., *lateritia* Cr. and *viridis* L. A key for the recognition of these species has been published by Ross<sup>2</sup>.

*Macrophya* is represented by *varia* Nort., five varieties of *trisyllaba* Nort. and *rapae* L. In all of these, with the exception of *rapae*, the apical half of the antennae is white. A key by Ross<sup>3</sup> identifies these with the exception of *rapae* which, at the time of writing, he considered to be *Pachyprotasis omega* Nort. We have captured the adults feeding on plant-lice and on a small sawfly, *Empria*.

*Tenthredo* is represented by 23 known species. All of those which we have taken have been determined by Dr. H. H. Ross. There is, unfortunately, no recent key available for the North American species of this genus in either sex though Smulyan<sup>4</sup> has prepared one for those which occur in New England.

<sup>1</sup>Ross, H. H. Illinois Biol. Monog., Vol. 12, No. 3, 1929.

<sup>2</sup>Ross, H. H. Pan Pac. Ent., Vol. 19, p. 128, 1943.

<sup>3</sup>Ross, H. H. Ann. Ent. Soc. Am., Vol. 24, p. 128, 1931.

<sup>4</sup>Smulyan, M. T. Proc. Bost. Soc. Nat. Hist., Vol. 36, p. 383, 1923.

For this reason, we have prepared for our own use one to include all of the females now known to occur on the Canadian prairies and in the adjacent woodlands and mountains. Dr. O. Peck generously loaned us specimens from the National collection at Ottawa. Two additional species, one of each taken respectively in Manitoba and in Saskatchewan, added to our known list for the prairies.

Our key has enabled us to place all specimens taken subsequently to its preparation, and we believe that it may be useful to others for this purpose. It is realized that a key, based largely on colour, has serious limitations in providing for the great variations which occur in the group under consideration. Attempts have been made to allow for all of the extremes which have been encountered in moderately long series of a number of the species concerned. The term "yellow", for example, necessitates a somewhat wide application. In the same species this may vary, particularly on the abdominal segments, from ivory to an orange which might almost be considered as red.

Yellow to red suffusions may occur on the cheeks or on the first abdominal segment in species in which these regions are, typically, entirely black. Such suffusions are, however, readily distinguishable from definitely bounded yellow spots.

In 1923 MacGillivray<sup>5</sup> described fifteen "new" species of sawflies from material collected by the late F. S. Carr in Edmonton. Subsequent studies of the genera there represented indicate that the majority of these species are synonyms.

In the United States Department of Agriculture "Catalogue of Hymenoptera"<sup>6</sup>, 17 species which have been recorded in the literature as having been captured in Alberta are now sunk into synonymy. This catalogue does not, however, include *T. alphia* MacG. of which we possess a specimen determined by Ross. We suspect that this may prove to be a synonym of *pectoralis* Nort.

We do not have access to specimens of *anomocerus*, *cinctitibiis*, *macgillivrayi* or *ruficollis*, all of which are recorded in the catalogue as occurring in Alberta. These have been placed in the key on characters as given in their original descriptions.

1. Antennae distinctly swollen on apical half; this is most pronounced when viewed laterally. (Subgenus *Labidia*) ..... 2
- Antennae filiform, usually tapering slightly from base to apex ..... 4
2. Apical joints fused to form an apically rounded club ..... 3
- All joints free, 3-5 slightly widened and flattened, apical joint tapering; body black, abdominal terga 4 and 5, and sometimes apical half of 3 contrastingly bright yellow. (Alta. foothills) *maxima* Nort.
3. Club slightly narrower than preceding joint; yellow on abdomen confined to lines on segment 2, an anteriorly sinuous band on 3 and apices of remaining segments. (Alta. mountains) *opima* Cr.
- Club as wide as flared apex of preceding joint; yellow of abdomen reduced to lateral spots on segments 1-3 and apical margins of remaining segments. (Alta. mountains) *anomocera* Roh.
4. Clypeus and mouthparts not contrasting with greenish-yellow colour prevailing on rest of body. (Alta. foothills) *stricklandi* Ross.
- Clypeus and mouthparts ivory to bright yellow in strong contrast with prevailing colour of most of the body ..... 5
5. Yellow on head confined to clypeus and mouthparts. Exceptionally with slightly reddish or yellow suffusions on the cheeks but never with a sharply defined coloured area here ..... 6
- Yellow on head extends on to epicranium, frequently confined to sharply defined areas on cheeks ..... 17

<sup>5</sup>MacGillivray, A. D. Can. Ent., Vol. 55, p. 158, 1923.

<sup>6</sup>Muesebeck, C. F. W. et al., U.S. Dept. of Agric., Monog. No 2, 1951.

6. Abdomen completely black, except for occasional yellow suffusions on the sides of tergum 1 ..... 7  
 Abdomen with sharply defined yellow areas and/or reddish to a varying degree ..... 13
7. Legs, beyond trochanters, largely red which may merge into black on the apex of the hind tibiae and on the tarsi ..... 8  
 Legs black and yellow or dull brownish-black, tarsi may be reddish ..... 11
8. Thorax with a red quadrate spot on pronotum. (Alta. mountains) *ruficollis* Harr.  
 Thorax black, with or without yellow markings ..... 9
9. All coxae predominantly black; all legs, posteriorly, often with a more or less complete black stripe; hind tarsi smoked with black. (Alta. woodlands) *erythromera* Prov.  
 At least mid and hind coxae almost completely red ..... 10
10. Anterior coxae usually about half black basally, hind legs always brown to black beyond the basal half of the tibiae. (Alta.) *leucostoma* Kby.  
 Legs almost entirely red, often yellowish anteriorly, black confined to extreme bases of coxae. (Alta. foothills) *fraternalis* Ross.
11. Legs blackish with no sharply contrasting yellow marks ..... 12  
 Legs black with a slender yellow line on all four anterior femora and on all tibiae; tarsi yellow with reddish suffusions. (Alta.) *cinctitibiis* Nort.
12. Black of legs merges to brownish beyond the basal half of the femora on some or all of the legs. (Man. to Alta.) *concessa* Nort.  
 Legs black though apices of femora and all of tibiae may be distinctly yellowish anteriorly. (Alta. foothills) *subcoerulea* Esch.
13. Abdomen black and yellow, always with bright yellow on tergum 1, often confined to its sides; tergum 5 yellow which may tend to orange. (Alta. woodlands) *borealis* Prov.  
 Abdomen black and/or red, yellow if present is confined to slight suffusions on the sides of tergum 1 ..... 14
14. Whole body predominantly red though black may encroach over large areas. Scape apparently always red. (Alta.) *xantha* Nort.  
 Except on cheeks with no red on head, thorax or base of the abdomen; pronotal angles, &c. often yellow-flecked ..... 15
15. Abdomen entirely black. (Alta.) *concessa* Nort.  
 Abdomen black and red ..... 16
16. Legs black and red, red of abdomen often pronounced only near its centre, cheeks with reddish suffusions. (Alta.) *concessa savanna* Ross.  
 Legs black excepting anterior sides of fore-tibiae which are usually dull yellowish brown; abdomen entirely red on its apical half. (Alta.) *attracta* Nort.
17. Yellow of epicranium confined to the cheeks, rarely with a very small additional spot at upper ends of eye-margin ..... 18  
 Yellow extends upwards to at least as far as the bases of antennae but is often most pronounced along the inner eye margins, may be interrupted near antennal bases ..... 26
18. Abdomen entirely black, with exception of occasional faint yellow suffusions on the side-margins of tergum 1 ..... 19  
 Abdomen with some yellow, this may be confined to a well-defined spot on each side of tergum 1, usually much more extensive, the apical half of the abdomen may be largely red ..... 20
19. All legs are red beyond the extreme bases of the coxae, somewhat yellowish anteriorly. (if the coxae are black, this is an aberrant *erythromera*). (Alta. foothills) *fraternalis* Ross.  
 Apical half of posterior femora and all of tarsi, with the exception of the last joint, black. (Sask.) *mellicoxa* Prov.



20. Yellow of otherwise black or black and red abdomen confined to tergum 1..... 21  
 Abdomen with additional yellow which varies from cream to orange..... 22
21. Some or all of pronotal angles, tegulae and mataepisterna are cream-yellow to orange; fore and mid legs pronouncedly dull yellow anteriorly, hind femora red. (Alta.) *pectoralis* Nort.  
 As above but mid-legs, only, with a trace of yellow, hind femora black. (Alta. foothills) *alphia* MacG.
22. Three indefinite longitudinal mottled-white lines on abdomen, laterally these are most pronounced basally and the median one apically (Alta.) *rurigena* MacG.  
 No indistinct longitudinal lines on the abdomen..... 23
23. Abdomen entirely black basally, red beyond 4th tergum, four front legs with a varying intense black anterior line, hind legs chiefly black. (Alta. woodlands) *exima* Nort.  
 Abdomen with some yellow posterior to tergum 1..... 24
24. Yellow confined to extreme sides of the basal half of the abdomen, which is black centrally, apical half of abdomen red (Alta.) *varipicta* Nort.  
 Tergum 5 entirely yellow..... 25
25. Abdomen posterior to tergum 5, except occasionally the base of tergum 6, black; scape usually orange but may be black (Alta.) *borealis* Prov.  
 Terga 7-9 with light yellow marks; scape bright yellow. (Sask. to Alta.) *basilaris* Say.
26. Yellow of epicranium hardly extends above base of antennae; prevailing colour of body red though black may invade considerable areas of all regions..... 27  
 Yellow of epicranium extends to upper ends of eye-margins though it may be interrupted near the centre of the eye..... 28
27. Usually with numerous yellow marks on thorax; inter-antennal lobes unusually small; area around and in front of ocelli minutely striate and dull (Alta.) *piceocincta* Nort.  
 Yellow marks, if present, usually confined to metaepisterna; inter-antennal lobes of usual size; dorsum of head sub-shining, not striate (Alta.) *xantha* Nort.
28. Inner eye-margins entirely yellow bordered..... 29  
 Yellow of eye-margins interrupted opposite base of antennae; abdomen black on basal half with narrow yellow borders, red on apical half. (If sterna are black, this is var. *magnifica* MacG.), (Alta.) *varipicta* Nort.
29. Thorax predominantly red, but often with some blackened areas and yellow markings (Alta.) *macgillivrayi* Smul.  
 Thorax black and yellow or brownish yellow..... 30
30. Thorax black and yellow; legs largely pale yellow and red with apices of hind femora and tibiae blackened (Alta.) *pallicola* MacG.  
 Thorax, abdomen and legs all brownish-yellow with little contrast in colour anywhere. (Man.) *mellinus* Nort.

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## The Eastern North American Subspecies of the Barberry Geometrid (Lepidoptera)<sup>1</sup>

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Until 1951 the Canadian National Collection of Insects lacked specimens of the barberry geometrid, *Coryphista meadi* (Packard), from Eastern Canada. In that year Mr. W. E. Whitehead, Macdonald College, Que., forwarded for identification two specimens taken in Kings County, N.S., and on learning of the interest of the record he kindly presented them to the National Collection. In 1952 an outbreak of the species in the Ottawa region caused minor damage to ornamental barberry bushes. Several enquiries about the insect were received, and MacKay (in preparation) studied its life-history.

Forbes (1948) notes that the eastern population of *C. meadi* is racially distinct from that of western North America. This conclusion is confirmed by material in the C.N.C. Although all the available specific names apply to the western form, Forbes did not name the eastern subspecies. In order to supply the lack I give the following description.

### *Coryphista meadi atlantica*, new subspecies

Figs. 1, 2

Dimorphic. Nominate form:—Head, thorax, and abdomen dull brown, paler below; abdomen above with one or more transverse black lines, tending to be interrupted by pale mid-dorsal spots. Wings dull brown above. Fore wing with broad antemedial and postmedial lighter bands, and some lighter variegation elsewhere; basal area with two obscure, irregular dark lines; antemedial band bounded inwardly and outwardly by distinct, irregularly wavy, black lines, and containing two to four indistinct, irregular, brown lines; antemedial band closely followed by the oval, oblique, black, discal dot; medial area with three wavy, brown, transverse lines, the first passing through the discal dot; postmedial band outwardly diffuse, but defined inwardly by an irregular black line, strongly angled above  $M_1$ ; three brown lines in the postmedial band; a subterminal, crenulate, pale line, expanded just below  $Cu_2$ ; a terminal series of light crescents, margined inwardly with black; fringe alternately light and dark brown and with a dark-brown line in the base. Hind wing above warmer and much more uniform brown than fore wing, with a faint brown discal dot, followed by concentric crenulate lines, marked by dark or light radial dashes along the veins; a marginal series of black-edged, pale lunules, as on the fore wing. Fore and hind wings beneath lighter brown, with the crenulated transverse lines of the fore wing above weakly indicated, and with discal dots prominent and black.

Holotype, ♀, Irvington, N.J., Frank Lemmer. Allotype, ♂, Ottawa, Ont., Sept. 13, 1942, W. Krivda. Paratypes: 1 ♀, Trenton, N.J.; 2 ♀ ♀, Sinking Spring, Pa.; 1 ♀, Kings Co., N.S.; 4 ♂ ♂, Ottawa, Ont.

Type No. 6132, C.N.C.

Innornate form:—Differing from the nominate form in having the transverse ante- and post-medial bands of the fore wing broadly and contrastingly orange,

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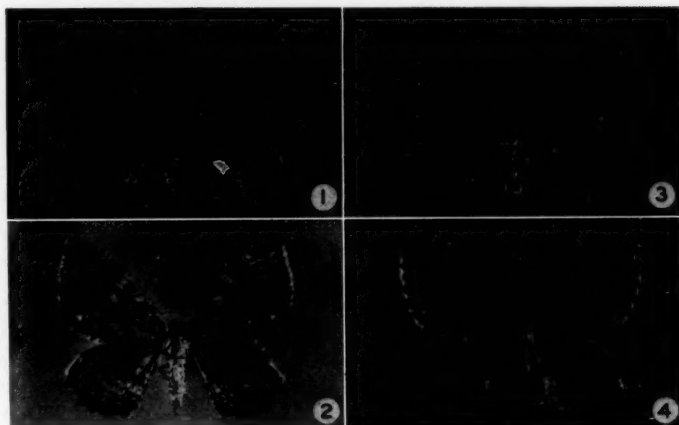


Fig. 1. *Coryphista meadi atlantica*, paratype, ♀. Sinking Spring, Berks. Co., Pa.; Aug. 23, 1936; H. C. Moyer.

Fig. 2. *Coryphista meadi atlantica*, orange-banded form, ♀. Trenton, N.J.; Aug., 1921; H. L. Bowers.

Fig. 3. *Coryphista meadi meadi*, nominate form, ♂. Okanagan Landing, B.C.; May 20, 1935; A. N. Gartrell.

Fig. 4. *Coryphista meadi meadi*, orange-banded form, ♂. Seton Lake, Lillooet, B.C.; June 15, 1926; J. McDunnough.

bearing indications of brown lines only at the costa; sometimes the hind wing with an orange postmedial patch. The equivalent of the form *badiaria* Hy. Edw. of *C. meadi meadi*.

Material examined: 15 specimens from Trenton and Irvington, N.J., and Ottawa, Ont.

The new subspecies differs in the nominate form from *C. meadi meadi* (Figs. 3, 4) in the much more variegated and mottled general pattern, with the transverse lines less well-defined, especially in the postmedial band; the orange-banded form is less clearly distinct from the corresponding form of *C. meadi meadi*, but has the medial area more variegated, and the discal dot of the fore wing larger and more distinct. There are no pronounced genitalic differences between the subspecies.

In Canada the range of the species is discontinuous. *C. meadi meadi* occurs regularly and commonly in southern British Columbia and the Cordilleran Region of Alberta; *C. meadi atlantica* occurs sporadically in Eastern Canada, as noted above. Forbes says that in the United States the species ranges from "Central New York to South Carolina, west to the Pacific".

#### References

- Forbes, Wm. T. M. 1948. Lepidoptera of New York and neighbouring states. Part II. Cornell Univ. Agr. Expt. Sta. Mem. 274.  
MacKay, M. In preparation. The egg and larva of *Coryphista meadi atlantica* Munroe (Lepidoptera: Geometridae).

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## The Egg and Larva of *Coryphista meadi atlantica* Munroe (Lepidoptera: Geometridae)<sup>1</sup>

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Eight larvae of the new subspecies *Coryphista meadi atlantica* Munroe, the barberry geometrid, were reared from eggs. Hatched eggs, first-instar larvae, head capsules of the various instars, one last-instar skin, and seven last-instar larvae were preserved for the present study. The head capsules indicated only four instars. The female adults were identified by Dr. E. G. Munroe, Systematic Entomology Unit, Entomology Division.

**Egg** (Figs. 2 and 6).—Length about 0.77 mm.; width about 0.55 mm.; depth greatest at end containing micropyle, 0.43 mm.; flattened on each side, blunt at end containing micropyle and where larva emerges, rounded at other end; surface reticulated; colourless when first laid, becoming creamy later.

**First Instar** (Figs. 8, 9, 16, 21-25).—(Seven larvae and four head capsules studied) Approximate length 2.2 mm.; head length 0.29 mm.; head width 0.33 mm. Epicranial index 1.4 or 1.5. Integument granulose; head and body cream or pale yellow. Setae long and quadrifurcate at tips, except on thoracic legs, prolegs, and setae D2 on the posterior abdominal segment. Spiracles circular. Crotchets uniserial, uniordinal, arranged in a mesal penellipse, numbering about 16 on ventral proleg, and 17 or 18 on anal proleg.

Head capsule with frontal setae (F<sup>1</sup>) more or less equidistant from epistomal setae (E<sup>2</sup>) and adfrontal setae (Adf<sup>1</sup>). Labrum about twice as broad as long, with a shallow notch on anterior margin. Mandible with a sharp tooth ventrally opposite condyle, four sharply pointed teeth, a rounded fifth on the upper part of the cutting margin, and two distinct internal ridges leading from first and third teeth of group of four to dorsal area of mandibular socket. Spinneret tapered from near base to tip; length about five times width. Labial palp with segments in proportion of 9:4:9.

Body setae of first instar considerably fewer in number than those in last instar as indicated in setal maps.

**Second Instar** (Figs. 10 and 11).—(Four head capsules studied) Head capsule: approximate length 0.57 mm.; approximate width 0.64 mm. Mandible similar to that of first instar but with a short crenulate edge appearing in place of a fifth tooth, and a short ridge extending from the fourth tooth parallel to the others. Labrum as in first instar.

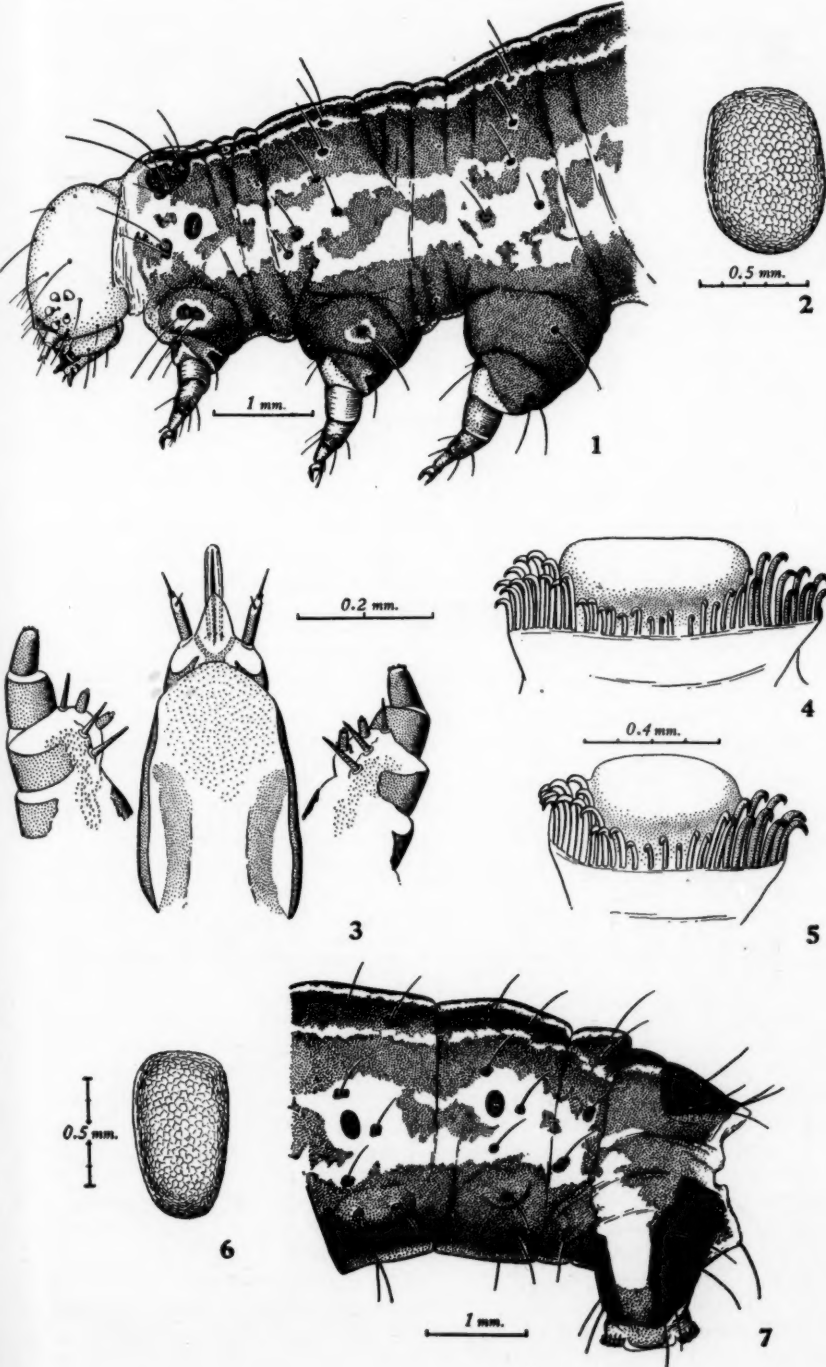
**Third Instar** (Figs. 12 and 13).—(Five head capsules studied) Head capsule: approximate length 0.93 mm.; approximate width 1.11 mm. Mandible with teeth somewhat broader and blunter than in earlier instars, and with edge on upper part of cutting margin more pronounced. Labrum with notch somewhat deeper than in earlier instars.

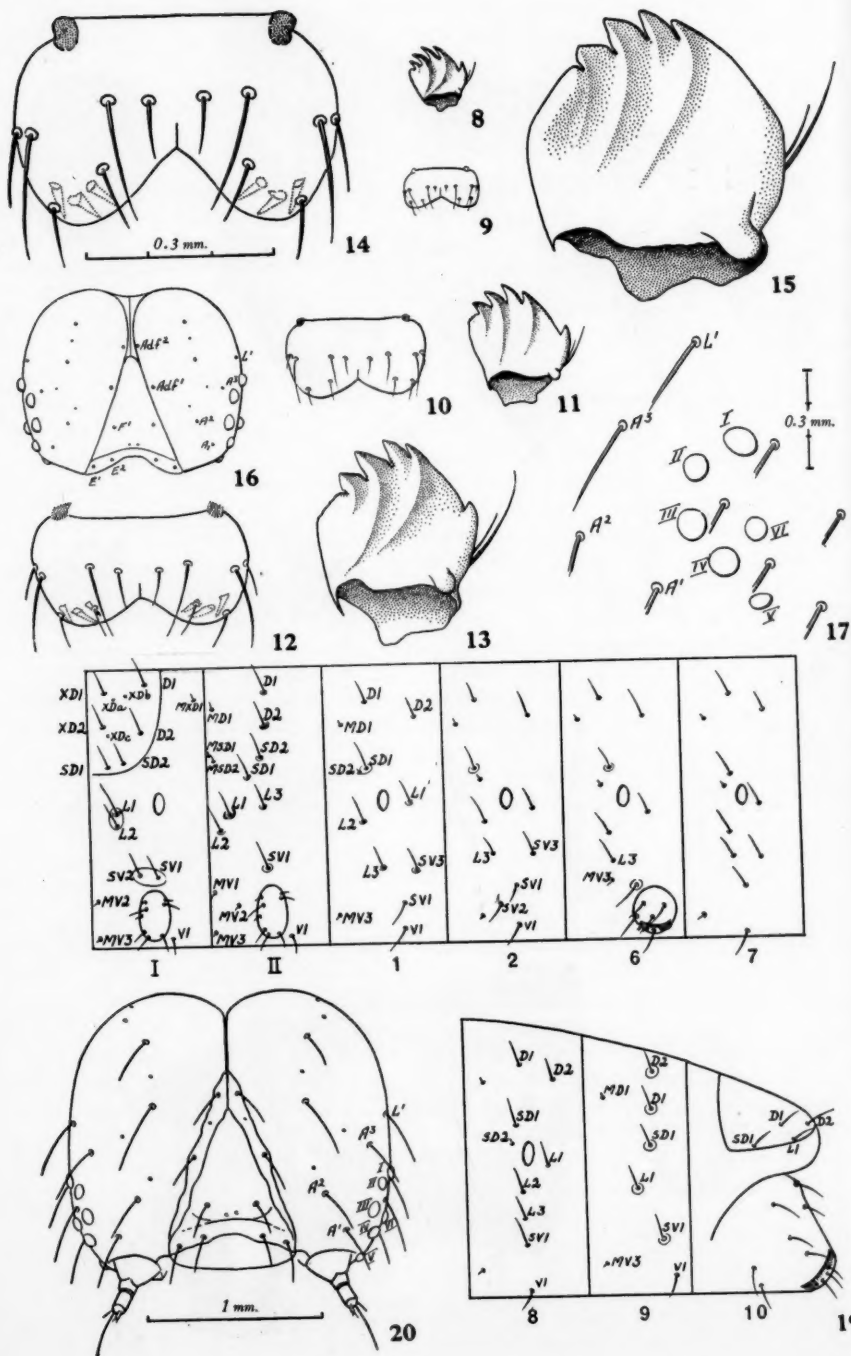
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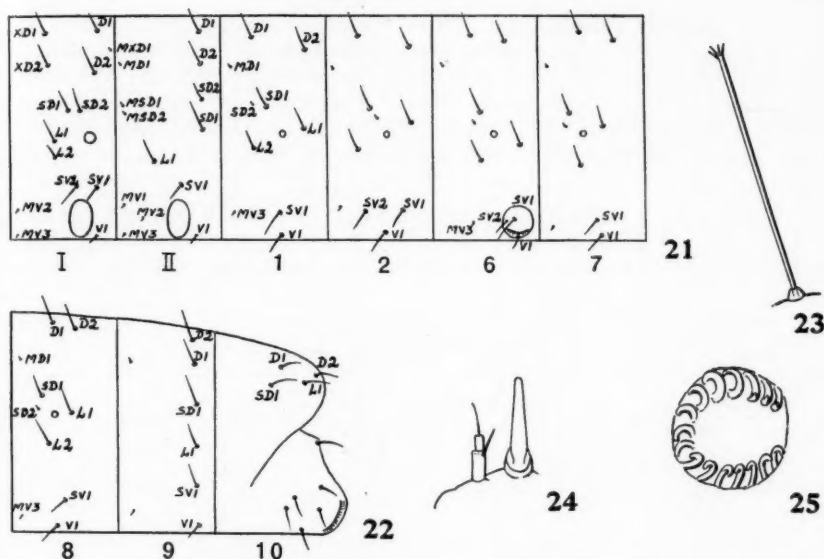
Figs. 1-25.—*Coryphista meadi atlantica*.

Figs. 1-7. 1, Head and thoracic segments of last instar. 2, Egg in natural position. 3, Spinneret and hypopharynx. 4, Median view of left anal proleg. 5, Median view of left ventral proleg. 6, Egg on edge. 7, Posterior abdominal segments of last instar.









Figs. 8-20. 8, 9, First-instar mandible and labrum. 10, 11, Second-instar labrum and mandible. 12, 13, Third-instar labrum and mandible. 14, 15, Fourth (last)-instar labrum and mandible. 16, First-instar head capsule (Figs. 8-16, same magnification). 17, Last instar, relative positions of ocelli and surrounding setae. 18, Last instar, setal map of first and second thoracic segments, 1st, 2nd, 6th, and 7th abdominal segments. 19, Last instar, setal map of 8th, 9th, and 10th abdominal segments. 20, Last instar, setal map of head capsule.

Figs. 21-25. 21, First instar, setal map of first and second thoracic segments, 1st, 2nd, 6th, and 7th abdominal segments. 22, First instar, setal map of 8th, 9th, and 10th abdominal segments. 23, First instar, body seta. 24, First instar, spinneret and labial palp. 25, First instar, ventral view of left ventral proleg.

*Fourth (Last) Instar* (Figs. 1, 7, 17-20).—(Seven larvae and one last-instar skin studied) Approximate length 25 mm.; approximate head length 1.57 mm.; approximate head width 1.87 mm. Epicranial index about 1.3. Integument smooth; body patterned longitudinally; ground colour brownish-black. Dorsum of ground colour with a pair of very narrow longitudinal white dorsal lines and a similar pair of lateral lines, the dorsal ones beginning anterior to prothoracic shield but not crossing it and extending onto the ninth abdominal segment, the lateral ones crossing the prothoracic shield and extending onto the tenth abdominal segment as far as the anal shield. Spiracular line broad, white with some brownish-black areas at intersegments, extending onto anal proleg. Ventrums brownish-black with a pale midventral line. Setal bases set in small, dark, sclerotized areas, which, in the SV1 and SV2 groups on the prothorax and sometimes on the mesothorax are conspicuous because of a surrounding area of white pigment; setae moderate in length. Spiracles oblong-elliptical, dark-centred, and dark-rimmed. Prothoracic shield almost black, crossed by a narrow middorsal line of white and the narrow lateral lines. Anal shield well defined and black; setae D2 closer to setae L1 than to each other. Anal proleg shield well defined and black, but divided by the white spiracular line. Ventral proleg shield well defined but lighter in colour. Thoracic legs brownish-yellow. Crotchets uniserial, arranged in a meseries, numbering about 28 on the ventral proleg and about 36 on the anal proleg.

Head (Figs. 17 and 20) light orange-yellow with no pattern. Anterior seta 2 ( $A^2$ ) usually closer to  $A^1$  than to  $A^3$ . Frontal setae ( $F^1$ ) usually closer to  $E^2$  than to  $Adf^1$ . Ocellus II more, or less equidistant from I and III, the distance being about that of its diameter. Median longitudinal width of postclypeus about half that of preclypeus. Labrum (Fig. 14) width about one and two-thirds times length; anterior margin deeply emarginated, sides of notch forming an angle of about  $87^\circ$ .

Mandible (Fig. 14) with five teeth, the first four bluntly pointed, the fifth straight-edged; ventral tooth opposite condyle of earlier instars lacking; ridges extending from first, second, and third toward dorsal area around mandibular socket.

Spinneret (Fig. 3) slightly longer than labial palps; length four and one-half or five times width. Labial palp with second segment, and seta of proximal segment, much reduced in comparison with those of first instar. Free margin of maxillary blade with no teeth; lobes clothed with extremely minute spines (apparent only under high magnification); gorge bare; lingua granulose.

*Remarks.*—The eggs hatch a few days after being laid, and the larvae reach the pupal stage in about two and one-half weeks, probably requiring soil within which to pupate.

The author has discontinued using the Fracker system in the nomenclature of setae in larval descriptions in favour of the Hinton (1946) system, which considers the primary, microscopic setae as well as the long, or tactile, setae.

#### Reference

- Hinton, H. E. 1946. On the homology and nomenclature of the setae of lepidopterous larvae, with some notes on the phylogeny of the lepidoptera. *Trans. Roy. Ent. Soc. London* 97: 1-37.

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